BARNWELL GEOTHERMAL CORPORATION

July 8, 1991

91 JUL 8 P4:55

DIV. OF WATER &
LAND DEVELOPMENT

Mr. Manabu Tagomori
Deputy Director
State of Hawaii
Dept. of Land & Natural Resources
P.O. Box 373
Honolulu, Hawaii 96809

Dear Mr. Tagomori:

Barnwell Geothermal Corporation ("BGC") has engaged in the exploration for geothermal resources within the County of Hawaii, having drilled a total of three geothermal test wells and one side track from one of the wells. Of the four drilling efforts, three were drilled within the lands demised by the State Geothermal Lease, R-3. In particular, BGC drilled the Lani Puna 1 well, a side track to that well and later drilled the Lani Puna 6 well. As a result of this drilling, which occurred during a four year period ending in late 1984, BGC determined that while the Lani Puna 1 well and its side track were quite hot, neither intersected the fractures necessary to make the well productive. The Lani Puna 6 well encountered a zone of extremely high permeability, but at too low a temperature to make it useable as a producing well. However, the depth of the permeable zone makes the Lani Puna 6 well an excellent candidate for use as an injection well.

There has been a significant delay since the completion of the Lani Puna 6 well, during which time we have worked to lay the ground work necessary to continue further exploration. In particular, we at BGC have analyzed the likely resource and worked with other parties to develop a rational plan for continued exploration. Having completed a significant initial exploration program, during which BGC discovered many features of the geothermal resource within the State Geothermal Lease including a likely injection site, and with the work done after our last drilling effort, BGC is now prepared to begin a second phase of exploration within R-3.

During the last year and a half, BGC has worked with Morgan Oil, Ltd. ("MOL"), a Kentucky company engaged in natural gas exploration and development, to reach an agreement to continue the exploration for geothermal resources within the lands demised by the State Geothermal Lease, R-3. BGC and MOL have reached substantial agreement on the form of a working relationship and, to date, the two companies have expended well in excess of $100,000 in engineering and legal fees.

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While working towards the agreement, BGC and MOL strove to develop a sound strategy for further exploration within the State Geothermal Lease. Enclosed with this letter are (1) a reservoir analysis performed by Geothermex, Inc., clearly setting forth the very high likelihood of commercial geothermal production from within R-3, (2) a drilling plan, setting forth a prudent well design consistent with the known reservoir characteristics, and (3) a well testing and evaluation plan. Under the planned agreement, MOL will be appointed the Operator. MOL has begun the preparation of the applications for all permits necessary for the drilling of a geothermal well. Each of the permits, when complete, the County of Hawaii Geothermal Resource Permit, the Authority to Construct from the State Department of Health, together with the Geothermal Plan of Operations and the Geothermal Well Drilling Permit to be submitted to your department, will show that MOL plans to drill a test hole as soon as it receives all necessary permits.

Given the substantial work performed within the lands demised by the State Geothermal Lease, the detailed planning completed during the last year and a half, the continuing efforts and desire to commence drilling operations as soon as possible, we request that the Department of Land and Natural Resources extend the R-3 lease so that we can continue to explore and develop a viable geothermal resource.

Sincerely,

Martin L. Jokl

Martin L. Jokl
President

Enclosures

MLJ/rz

cc: Charles L. Culton

ANALYSIS AND RECOMMENDED DEVELOPMENT OF BARNWELL ACREAGE, PUNA GEOTHERMAL FIELD, ISLAND OF HAWAII

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ANALYSIS AND RECOMMENDED DEVELOPMENT OF BARNWELL ACREAGE, PUNA GEOTHERMAL FIELD, ISLAND OF HAWAII

for

BARNWELL INDUSTRIES
Honolulu, Hawaii

by

GeothermEx, Inc.
Richmond, California

November 1989

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CONTENTS

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ILLUSTRATIONS

Figure

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1. SUMMARY

GeothermEx was retained by Barnwell Industries (Barnwell) to make an independent assessment of the prospective development of the combined leasehold and fee acreage, total 45.05 acres, in the lower Kilauea East Rift Zone of Hawaii, for geothermal energy. The objective of Barnwell is to generate a minimum of 5 megawatts (MW) of electric power.

The existence of a commercial geothermal reservoir underlying the 45.05 acre Puna lease and fee simple lands of Barnwell (figure 1) at the southwestern part of the Kapoho Section of the Kilauea Lower East Rift Zone (KLERZ) geothermal subzone has been proven by six deep wells drilled by Thermal Power Company and Barnwell. Hot water and steam at temperatures of up to 680°F exist in a reservoir lying between the depths of 4,000 to 7,000 feet.

The field discovery well HGP-A was drilled in 1976 and has been supplying a 3 MW demonstration plant since 1982. Three Thermal Power Company wells (Kapoho State 1, 1A and 2) were drilled and flow-tested between 1981 and 1985. Of the three wells, Kapoho State 1A (KS-1A) is reported to have had a power capacity of about 3 MW (gross); while Kapoho State 1 (KS-1) and 2 (KS-2) were tested, and appeared to be capable of producing about 3 MW (gross) and 2 MW (gross), respectively. All 3 wells are now plugged, due to mechanical problems. Two other wells (Lanipuna 1 and Lanipuna 6) were drilled by Barnwell between 1981 and 1984. These two wells proved to be outside the main reservoir and therefore unproductive; but they provide valuable subsurface temperature

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and geologic information, and one of them (Lanipuna 6) is usable as an injection well.

Within the drilled area, the subsurface temperature is greater than 400°F at -4,000 feet, msl (figure 2) and there is a strong horizontal temperature gradient (1°F/16 feet) within the productive drilled area. Thermal fluid is apparently being channeled along steeply dipping structures paralleling the northeast-trending, 1955 eruptive fissure. There is relatively poor horizontal permeability in the northwest-southeast direction; flow is dominated by steep, northeast-trending structures. Based on the structure of older rift zones exposed elsewhere in the Hawaiian Islands, it is probable that the zones of good permeability are related to fracturing during dike emplacement. The dikes which form rift zones are individually only a few feet wide, dip from 90° to 70° and, in densely intruded areas, are spaced only a few feet apart.

Hydrological studies and chemical analyses of fluids produced from the deep Puna wells indicate that the thermal fluid is a mixture of fresh water and sea water, with the sea water component apparently increasing to the southeast, away from the fissure zone. This suggests that recharge to the system may be mainly meteoric in origin. Although various warm springs occur along the coast SE of the drilled area, the absence of large hot springs indicates that the system discharges in the subsurface.

Reservoir liquid compositions including high silica concentrations and high H_2S/steam require appropriate drilling and production engineering to avoid the risks of silica scaling and

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corrosion in well casings, separators, outlet pipes, valves and injection wells.

A hydrogeological model of the geothermal system suggests that different reservoir areas can be defined with varying degrees of certainty concerning their potential reserves; the two areas are referred to in this report as "proven" and "probable" in decreasing order of certainty. The "proven" area, defined by successful production wells drilled to date, is estimated to be about 0.2 square miles, centered about 500 feet northeast of KS-1A. The area is probably asymmetric with a long axis paralleling the 1955 eruptive fissure. The southeastern 70 percent of the Barnwell acreage is within this proven area. The "probable" area, defined by conservative geological extrapolation of the drilling results to date, is estimated to be about 0.5 square miles and includes the northwestern 30 percent of the Barnwell acreage. The total reserves of the Barnwell acreage may be estimated by a volumetric approach which is beyond the scope of this report.

Based on the production test results, principally from HGP-A, it is reasonable to assume that future wells producing from the same reservoir will have an average capacity of about 3 MW. Two production wells or if feasible one well with 2 productive legs therefore, should be required for a 5 MW (net) plant. The relative pressures found will determine whether a single well can produce from 2 legs.

It is anticipated that only one injection well will be required because of the high enthalpy of the fluid produced from existing wells. Because of its high permeability and location outside, but adjacent to,

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the high temperature reservoir, well Lanipuna 6, about 1 mile east and owned by Barnwell, is a likely candidate for injection.

The general development strategy recommended for obtaining the required production is to drill the new well(s) from one pad located about 800 feet westward of well HGP-A, near the western part of Barnwell fee land. An alternate location is about 2,500 feet northwest of HGP-A on leased land. Drilling from the fee land may make permitting simpler and would allow two legs or two wells to be drilled, one vertical, one directed northerly within the proven area.

Drilling at the alternate site from northwest of the 1955 fissure on topographically higher ground may help protect the wellhead from any future eruption; this location would afford the drilling of a directional well or leg into the proven area of the resource near the extension of the mapped 1955 fissure, as well as a vertical well or leg into the probable area. This drilling strategy, which would result in the wells reaching reservoir depth at an average horizontal spacing of more than 800 feet, should not cause undue interference between the wells.

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2. GEOLOGY

The Puna geothermal field is located on the East Rift Zone of Kilauea volcano (figure 1). The East Rift extends from Kilauea's central caldera in a 25-mile linear course to the northeast coast of the island with a further 43-mile submarine extension. In the vicinity of the Barnwell acreage, the rift is about 1.5 miles wide, as indicated by both surface morphology and aeromagnetic anomalies.

At the surface the rift zone is marked by open fissures and lines of cinder and spatter cones. From knowledge of older rifts in the Hawaiian Islands, now exposed by erosion, rift zones in the subsurface consist of swarms of closely spaced, nearly vertical, and nearly parallel dikes. In the central part of a main fissure zone, the number of dikes, which average 3 to 5 feet in width, ranges between 100 and 200 per mile of zone width, with a maximum of about 1,000 per mile. Along the length of the East Rift, including the Puna area, the most recently active fissures are located on the southern boundary of the dike complex which forms the rift.

Geologic information for the Puna field comes from:

a) surface geologic mapping and interpretation of air photographs

b) geophysical surveys; and

c) lithologic logs and "mud logs" available from exploration drilling.

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2.1 Surface Geologic Features

The most important, and obvious, geologic features within the area are the surface traces of fissures through which lava was erupted in 1955, marked by linear trends of small craters and by small scarps marking recent fault offsets. The fissures and scarps strike N 60° E in an *en echelon* pattern. The locations of these features, as mapped from large-scale air photographs, are shown in figure 1.

The fissure zone terminates at the small unnamed crater from which the extensive lava flow of 1960 was erupted. This vent is located 0.8 miles NW of Kapoho crater. Just to the southwest of wells KS-1 and HGP-A, the fissure zone is offset 0.8 miles to the southeast. It has been postulated by a number of geologists and geophysicists that this offset is an important "transverse fault" to which the Puna field is in some way genetically related. There are no northwest-trending fractures on the surface to indicate the presence of this postulated fault. The main evidences of its existence are a discontinuity in the trend of the magnetic pattern related to the rift dikes, and a strong northerly trend in the self-potential anomaly map (figure 2).

From the northwest-trending offset the main eruptive fissure extends another 6 miles to the southwest, but no recent eruptions have occurred along the 2-mile length nearest the offset. The Puulean craters (figure 1), which parallel the fissure just to the southwest of the offset, are old features with no record of historic eruptions.

2.2 Geophysical and Geochemical Surveys

A number of government-funded geophysical surveys were carried out over the East Rift during the 1970s. These included gravity, magnetic, seismic, and a variety of electrical surveys, including DC (bipole-dipole and pole-dipole), EM (time domain, variable frequency inductive sounding and transient sounds), mise-a-la-masse and self-potential (SP).

Of the many geophysical anomalies defined by these surveys, SP anomalies appear to be most closely associated with geothermal features, both in the Kilauea crater area, and the East Rift. Indeed, the discovery well of the Puna field, HGP-A, was sited, in part, on the basis of a large SP anomaly located north of Puulea crater. The hole was not sited directly on the anomaly because a lease for an appropriate site could not be obtained. Lanipuna-1 was sited and drilled on the anomaly, and was hot and dry.

The anomaly most closely associated with the surface trace of the main eruptive fissure zone is reported to be an anomaly caused by the concentration of mercury in near-surface soil samples. Again, as with the aeromagnetic anomaly, this anomaly shows the northwest-trending discontinuity near HGP-A presumed to be caused by a fault offsetting the rift trend. The highest concentrations of soil mercury, however, are not in the area of offset but over the northeast-trending fissure just to the northeast of the presently drilled area.

In summary, the geophysical and geochemical surveys located several anomalies. The anomalies, however, do not coincide with each other in area and therefore cannot be used with confidence to delineate

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the reservoir; nor do they have sufficient resolution to be useful for well siting.

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3. HYDROGEOLOGY

The characteristics of a hydrogeologic model for the Kilanea Lower East Rift Zone can be summarized as follows:

1. The increase of temperature to the northwest within the drilled areas, using HGP-A, Lanipuna 1, Lanipuna 1-ST and Lanipuna 6, and a strong horizontal temperature gradient (1°F/16 feet), indicate that thermal fluid is being channeled along steeply dipping structures paralleling the northeast-trending, 1955 eruptive fissure.

2. The temperature pattern suggests that a horizontal component of flow is directed from southwest to northeast parallel to the trend of the East Rift.

3. There is relatively poor horizontal permeability in the northwest-southeast direction, and flow is dominated by steep, northeast-trending structures.

4. Based on the structure of older rift zones exposed elsewhere in the Hawaiian Islands, it is probable that the zones of steep permeability are related to fracturing during dike emplacement. The dikes which form rift zones are individually only a few feet wide, dip from 90° to 70° and, in densely intruded areas, are spaced only a few feet apart.

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5. The thermal fluid is a mixture of fresh water and sea water, with the sea water component apparently increasing to the southeast, away from the fissure zone. This suggests that recharge to the system may be mainly meteoric in origin.

6. Although various warm springs occur along the coast southeast of the drilled area, the absence of large hot springs indicates that the system discharges in the subsurface. The basal ground water level is just above sea level, and an early exploration well found near-boiling temperatures at sea level just northeast of the drilled area. The thin (100 foot thick), high, temperature zone indicates the presence of lateral discharge on top of the local cold water table.

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4. RESERVOIR FLUID COMPOSITIONS

Dissolved solids in the Puna reservoir liquids are dominantly sodium (Na) and chloride (Cl). The overall composition commonly is characteristic of seawater hydrothermally altered during reactions with basaltic rocks, and diluted with about 25% to 50% meteoric water. An exception is the first production from well HGP-A, which was much more dilute and resembled meteoric water altered in basalts with or without a small altered seawater component. During its production history, the fluid from well HGP-A has slowly shifted to the altered seawater signature. Like the current production, the early production was an Na - Cl fluid, but with distinct ion ratios and much lower total dissolved solids.

There are strong chemical gradients in the reservoir. At well HGP-A the earliest production had average pre-flash reservoir liquid Cl at about 1,700 ppm, whereas the Cl level by 1984 was over 7,000 ppm. The increase in Cl occurred between 1981 (first steady production) and 1985, and the well has been stable since that time. The increasing Cl was accompanied by the above-mentioned changes in other ions, showing a shift from meteoric-hydrothermal to seawater-hydrothermal character. It thus appears that the well tapped a small, lower salinity hydrothermal system which contained mostly meteoric water altered by heating in basalts, and that depletion of this system has caused altered seawater to be drawn in, either from the side or below.

Horizontal gradients also exist. The present 7,000+ ppm Cl at well HGP-A compares with 12,000 - 14,000 ppm at KS-1A, about 17,000 ppm

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at Lanipuna 1, and 15,500 ppm at Lanipuna 6. These compare with 19,000 ppm Cl in seawater.

During the production of well HGP-A since 1981 its silica concentrations and silica temperatures have remained constant. It has been reported that Na-K-Ca temperatures have a value of about 480°F.

4.1 Non-condensible Gases

At well HGP-A, non-condensible gases (NCG) in steam have changed only slightly during production since 1981. Concentrations are as follows, showing the concentration in steam at initial production (1981) followed by the concentration 3-1/2 years later: CO_2 1,250ppmw/1,150ppmw; H_2S 950ppmw/850ppmw; N_2 130ppmw/120ppmw; H_2 12ppmw/12ppmw; CH_4 1ppmw/no data; total NCG 2,340ppmw/2,130ppmw. These concentrations were determined in steam separated at a typical pressure of about 155psig.

The CO_2/H_2S ratio in these gases is quite low compared to typical values in geothermal systems world-wide, and H_2S/steam is much higher than found in typical water-dominated systems. The unusual CO_2/H_2S ratio and high H_2S are probably related to the recent magmatic activity in the Puna area, and/or to reactions between seawater and reduced iron in hot basalt, which could reduce seawater sulfate to sulfide.

4.2 Risks of Development Related to Fluid Chemistry

The fluid chemistry at the Puna wells will impact geothermal development, requiring special consideration to avoid undue risks to

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safety and to project economics. The principal risks associated with fluid chemistry are silica scaling and the effects of the high H_2S in steam.

The reservoir liquid is considered to carry 780 ppm SiO_2 at 625°F, based on the solubility of quartz in a 2.84 wt% NaCl solution. This is a probable upper limit on reservoir SiO_2, because the actual reservoir salinity is probably closer to 2.0 wt%, and measured SiO_2 data suggest that the reservoir liquid production comes from a zone between 575°F and 625°F.

Silica scaling is known to be occurring in the production separator and flow lines at well HGP-A, where the normal separation pressure is 155 psig. Scaling also could increase if wells begin to produce brine combined with greatly superheated steam, generated during reservoir boiling. This would increase the concentration of the brine during boiling, but the increase may well be offset by a decrease in the brine flowrate. Reservoir boiling also will cause reservoir silica scaling which will reduce reservoir permeability. The loss probably will not be significant.

The amount of scaling in the production system at well HGP-A has not been prohibitive. At well HGP-A, the brine handling system was inspected in August, 1983, after about 22 months of production. The 10-inch diameter pipeline between the wellhead and primary separator contained a layer of vitreous silica scale, about 0.5 mm thick. The primary brine separator (4'-7" diameter; 17'-10" high) was coated with a scale of silica plus <5% iron sulfides (corrosion products), a few mm to 2 cm thick. In the outlet pipe downstream of the separator there was 0.5 to 2 cm of scale. However, there was evidence that the scaling in

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the outlet pipe had been enhanced by flashing in the pipe immediately downstream of the separator. It also was found that small diameter nipples and connection points such as sample points had been bridged by scale, probably because of heat loss or turbulence.

At lower temperatures in the HGP-A production system there is a problem with silica, because abundant flocculated silica has sealed the percolation ponds and required that they be greatly enlarged. If the injection well is much cooler than the fluid temperature at the mixing point (about 300°F), there will be some risk of scaling in the injection well and resulting loss of injectivity.

The high H_2S/steam may not present an abatement problem. However, the H_2S does present a significant corrosion potential, and it requires that the condenser and (re-)injection system be well-sealed and maintained at positive pressure at all times to avoid intrusion of oxygen from the atmosphere.

The potential for corrosion of well casings and surface lines is principally from sulfide stress cracking along interior surfaces. When the HGP-A production system was overhauled in August, 1983, there was relatively little evidence of corrosion in air-free parts of the brine system. In the steam supply system there was some iron sulfide scale (corrosion products), and iron oxides where air had intruded, in thicknesses about 1 mm and less, at certain locations only.

We should also note that there is evidence of boiling at the top of the thermal system near sea level, some 600 ft below the land surface. If the environment near sea level is receiving large amounts of H_2S rising from depth, and if this is mixing with oxygenated meteoric

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water percolating from above, there is considerable potential for development of acid groundwaters which can cause severe external casing corrosion at the surface of the water table. Well casings should be adequately designed to mitigate the impact of this (hypothetical) corrosion.

Finally, the general character of the Puna system presents some potential for a long-term increase in steam corrosivity. If the system draws in a higher and higher proportion of seawater, this will cause a long-term increase in Cl and lowering of reservoir pH. These changes should not be a problem, unless the reservoir dries out significantly and begins to produce superheated steam, which could carry volatilized hydrochloric acid. Mitigation of the acid by injecting caustic into the steam flow, could become necessary. This risk is relatively remote, and speculative.

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5. RESERVES

Surface geology combined with subsurface temperature data indicates that the geothermal reservoir consists of thermal fluid circulating in fractures located within about 2,000 feet of the eruptive fissure of 1955. The temperature contours further indicate that fluid is moving parallel to the rift zone from southwest to northeast. Based on this hydrogeologic model, reservoir areas can be defined with varying degrees of uncertainty concerning their potential reserves. These are discussed below in order of increasing uncertainty of reserve estimate.

5.1 Area of Proven Production

The Proven area is defined by drilling results. It is bounded on the northwest by the eruptive fissure, and on the northeast by the 400°F isothermal surface, assuming that 400°F is the cut-off of economic production for a flash-cycle plant. Because the temperature contours expand downward the proven area also increases in extent and is about 0.2 square miles at
-6000 feet msl. Based upon an average radius of 1800 feet from a central point between HGP-H and KS-2, but with the evidence that the reservoir is asymmetric with a northeast-southwest long axis, the southern 70 percent of the Barnwell acreage is within the proven zone. The volume of the reservoir within the Barnwell acreage has not been calculated. This can be done using data from all existing wells for a volumetric analysis, with a probabilistic basis for some imprecise parameters.

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5.2 Area of Probable Production

The Probable area may be considered to be all that acreage above the 400°F at -4000 feet msl. This includes the remainder of the Barnwell leasehold.

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6. DEVELOPMENT STRATEGY

The general development strategy recommended for obtaining 5 MW (net) of production is to drill a vertical well, B-1, from one pad located about 800 feet west of the HGP-A pad (figure 2). From there, a directional well B-1A could also be drilled northward to intercept the trace of the 1955 fissure below -4,000 ft. msl. This drilling pattern would result in wells with an average horizontal spacing of about 800 feet at production depths, which should not cause undue interference between the wells.

Additional wells or a well with 2 legs could be drilled alternatively from a pad located on the north side of the fissure zone about 2,500 feet northwest of HGP-A. There are 2 reasons for this recommendation:

a) The first well or leg, B-2, drilled southward from the site toward the 1955 fissure, would drain an area significantly spaced (≥800 ft) from B-1A and B-1. The second well or leg, B-2A drilled vertically, would test the "Probable" area northward of the 1955 fissure.

b) Because topography slopes to the south, the 1955 lavas all flowed to the south of the fissures from which they erupted. Therefore, the wells and plant may be located on the north side

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of the fissure for greater protection from possible future lava flows.

There appears to be justification to drill and test the 45 acres currently controlled by Barnwell. A 5 MW development including well(s) and wellhead generators is proposed for an initial effort.

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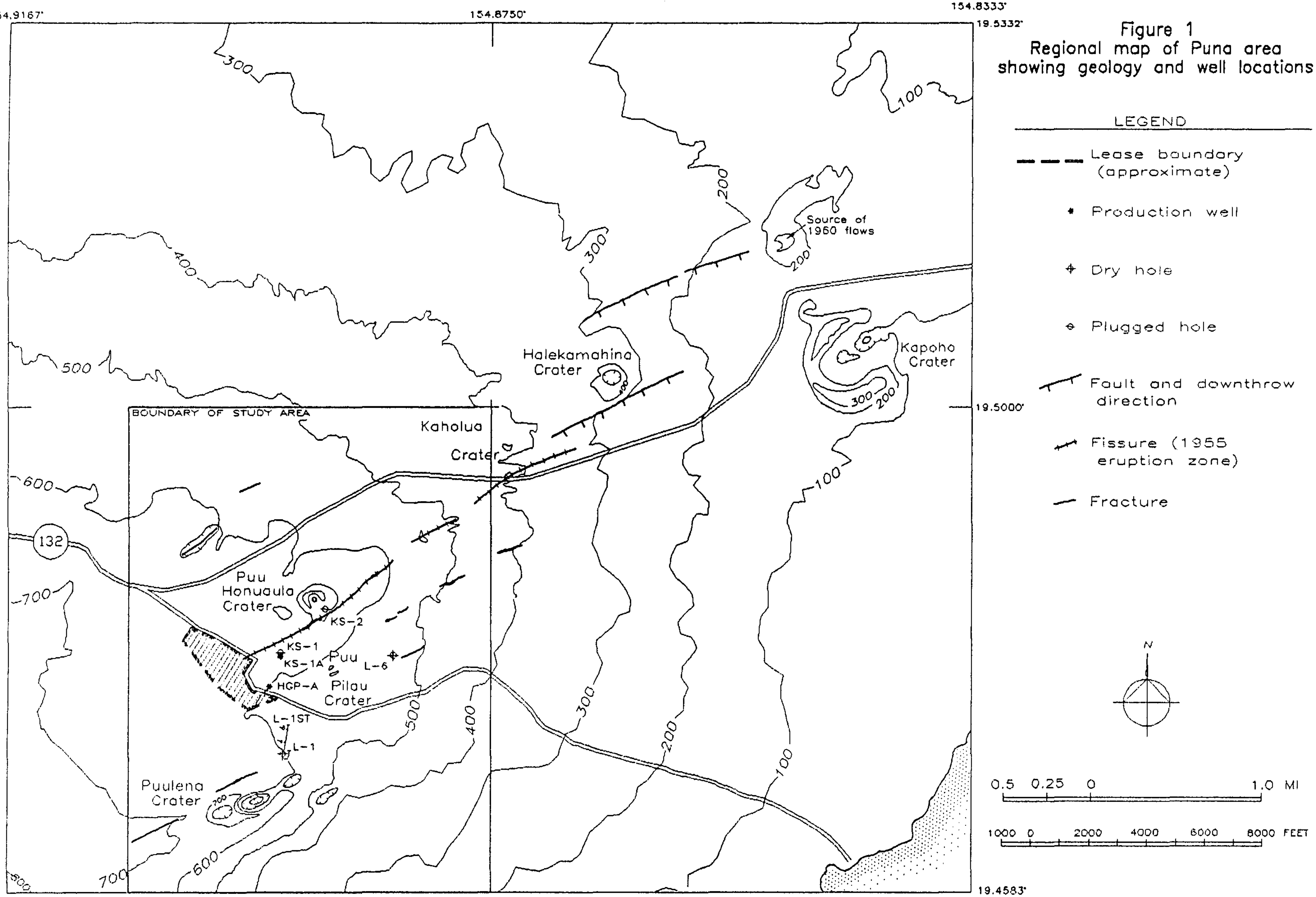
FIGURES

Figure 1
Regional map of Puna area
showing geology and well locations



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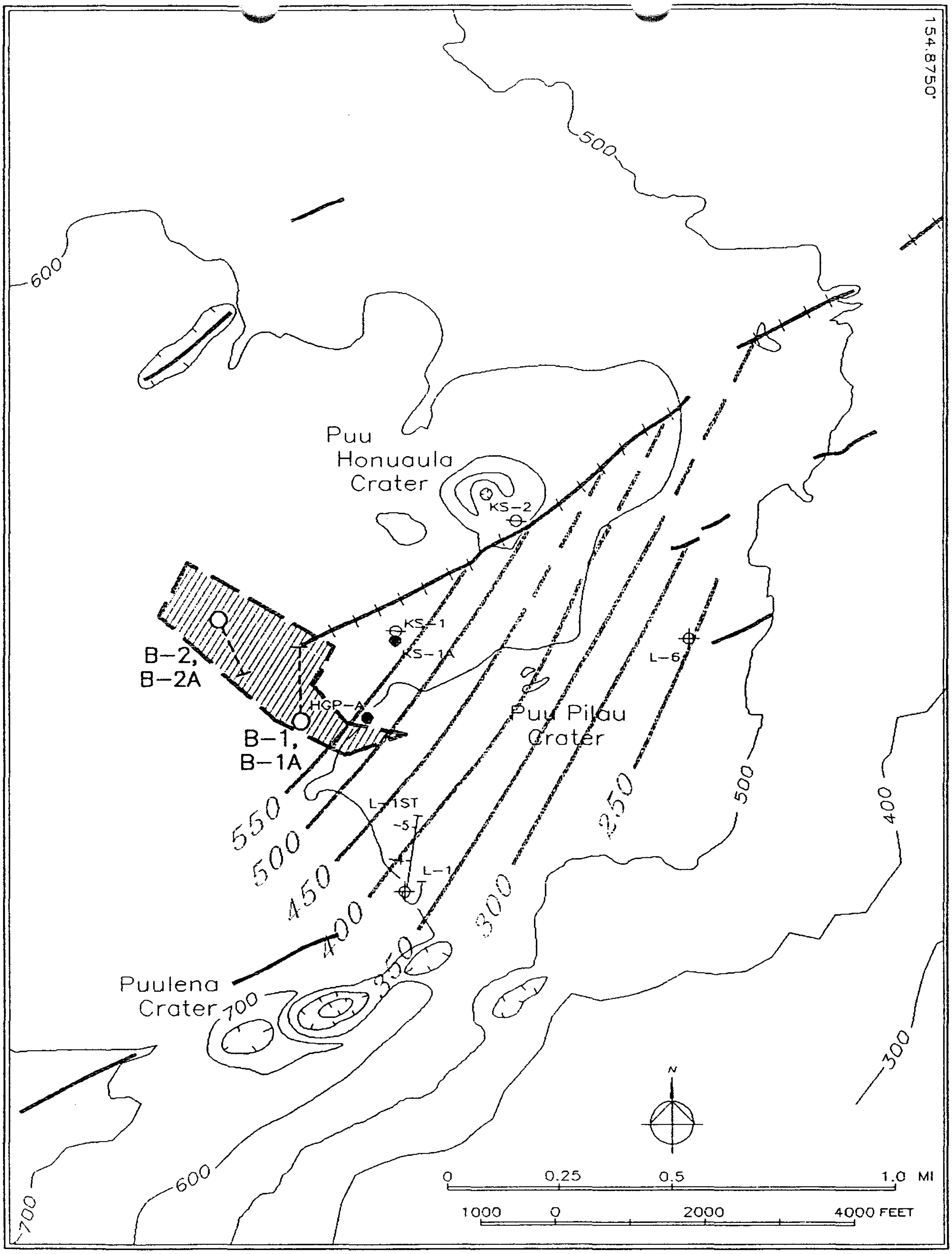
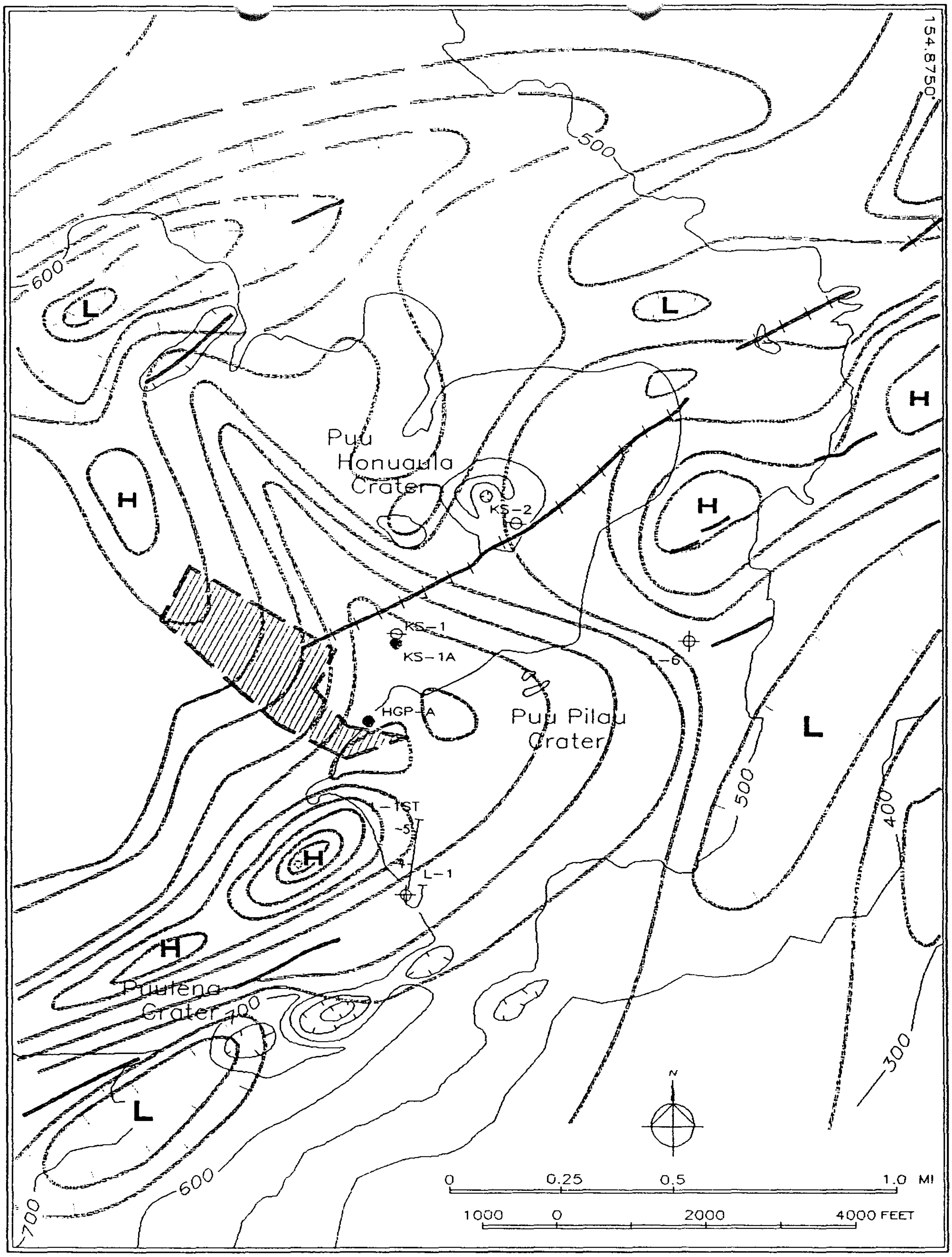


LEGEND

400 Temperature, °F	Production well	Fault and downthrow direction
Lease boundary (approximate)	Dry hole	Fissure (1955 eruption zone)
Recommended well site	Plugged hole	Fracture

Figure 2. Temperature distribution at −4,000 feet, msl

 BWPUNA2/112283/H2263



LEGEND

Self-potential contour showing 50 mV interval (H=high; L=low)

Lease boundary (approximate)

Production well

Dry hole

Plugged hole

Fault and downthrow direction

Fissure (1955 eruption zone)

[illegible]ucture

Figure 3. Local self-potential anomaly map

DRILLING WORKSHEET
PUNA WELL ....
PUNA DISTRICT - HAWAII

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BARNWELL

DRAFT

DRILLING WORKSHEET

PUNA WELL ....

PUNA DISTRICT - HAWAII

WELL DATA:

LOCATION:

ELEVATION:

OBJECTIVE: Drill steam producer to 7,500 MD (maximum)

STATUS: New well

DRAFT

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SIMPLIFIED GEOLOGY

FORMATION	DEPTH	LITHOLOGY
Alluvium	0′ - 150′	Alternating layers of silt, clay and unsorted basalt gravel.
Sub-aerial Basalt	150′ - 1,300′	Dense basalt with alternating layers of vent tubes. Severe losses of circulation expected from 300′ to 1,300′
Water Table	620′ - 650′	Depth to sea level
Submarine Basalt	1,300 - TD	Dense basalts with alternating layers of volcanic ash. Losses of circulation possible below 4,300′

DRILLING PROGRAM

The following drilling program supplements the Geothermal Drilling Permit application submitted herewith. This well is an exploratory hole, aimed principally to obtain information and possible production from depths below 4,000 feet in the Puna KGRA, and to confirm the resource in the area located westward of the Kaopoho State wells drilled in 1981-1982 and westward to north-west of the HGPA well drilled in 1976.

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I. PRELIMINARY CIVIL WORK

WELL PAD

Build a well pad and access road, according to civil engineer's specifications. Approximate rig and mud pit configuration and distribution are shown on Figure 1. Pad floor must be conformed of selected, compacted material, particularly where rig is to be placed. Soil compaction must be suitable to support the rig gross dead-weight plus 400,000 pounds live-loads. If soil minimum requirements can not be fulfilled, arrange to build crossed wood-matting from 6"X6" pieces to distribute the rig's weight. Where grading of the original soil is required, minimize the volume of fill, particularly where the heavier machinery is to be placed. Rig location must be over cut area or improved and compacted material. Access roads must be able to support heavy and frequent traffic. The area must be properly drained, avoiding accumulation of water around the work area.

CELLAR

Build a reinforced concrete cellar, 12 X 12 X 10 feet deep, according to civil engineer's specifications. Remove any large boulder rocks from the bottom. If feasible, place a drain from the cellar bottom to the mud sump, minimum size 6-inches with a 2% gradient sumpward.

MUD PIT

Build a mud sump, according to the civil engineer's specifications, of 300,000 gallon useful capacity, to provide for drilling and for initial

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phases of the well testing. Line the sump with bentonite or, if so required by State regulations, with plastic material.

CONDUCTOR PIPE AND RAT-HOLE

Drill a 36-inch hole to 50 feet, centered in the cellar, using a rat-hole digging auger. Cement a 30-inch steel pipe (conductor) into the hole, using a cementing contractor, and maintain cement level in the annular space. Use "ready-mix" cement, prepared with Class A cement, for temperatures below 170° F, similar to ASTM 150 Type I cement, for moderate sulfate resistance. The recommended water/cement ratio, according to API, is 0.46 by weight of cement (5.2 gallons per sack). The slurry bulk volume is 1.18 cu.ft/sack. This slurry thickens in about 3 hours and reaches 2,000 psi compressive strength after 72 hours, at normal temperature conditions. Conductor contractor must also dig the rig's rathole, using a 14 or 16-inch auger; the location and depth shall be specified by the drilling contractor.

II. WELL DRILLING

26-INCH STAGE

1. Move-in drilling equipment. A diesel-electric rig will be used. Weld-on a 30 X 20 inch adaptor flange. Attach 30-inch flow nipple with fill-up and flow lines (figure 2).

2. Install H2S monitoring equipment. Begin mud logging. Drill a 12-1/4-inch pilot hole to 650 feet. Notify State officer 24 hours prior to taking water sample. At 650 feet depth, rig up bailing

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tools. Bail out well until clear fluid is withdrawn from bailer. Obtain two separate samples of fluid. Send samples to lab for analysis. Have state officer to witness the sampling procedure. Condition the hole and resume drilling 12-1/4-inch hole to approximately 1,400 feet. Significant losses of circulation are expected to occur below 300 feet level. Attempt to cure losses using high viscosity mud and LCM. If losses persist, drill ahead with mud loss.

Precise casing point will be selected by site geologist and drilling engineer, on basis of lithology, loss circulation zones, and presence of firm rock. Take a drift shot at casing depth. Pick up 17-1/2-inch hole opener with 12-1/4-inch bit, reamer, 12-inch shock absorber and 17-1/2-inch stabilizers, and open hole to 1,400 feet. Repeat same operation using 26-inch hole opener and 17-1/2-inch bit, 26-inch reamer, shock absorber and stabilizer.

20-INCH CASING

3. Clean and condition hole. Run 20-inch, 106 lb/ft, Grade K-55, Buttress threaded casing to 1,400 feet. Equip casing as follows:

   - 20-inch guide shoe, welded

   - One casing joint above shoe

   - 20-inch stab-in collar/float

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- One centralizer above shoe; next, one joint up from shoe, and one every 90 feet (every third joint thereafter)

4. Run into the hole with drill pipe and stinger tip. Stab into collar and circulate 300 cu.ft of water and 300 cu.ft of light cement and calcium chloride preflush. Cement according to Casing and Cementing Prognosis, page 19.

5. Wait on cement for 6 hours thickening time. Cement returns are unlikely to occur. In case returns are not observed during cementing, pick up and run 1-1/4-inch tubing through annular space. Tag top of cement. Mix and pump Class G cement blended with 2% calcium chloride. Circulate to surface. Pull tubing and wash while laying down. Wait on cement 6 hours and repeat if cement top settles.

6. Cut 20-inch casing and install the 20-inch BOP assembly as follows (see figure 3):

   - Slip-on, 20-inch, 2M, ANSI Series 600, casing head, equipped with two 3-inch outlets.

   - 20-inch, 2M, ANSI 600, drilling spool

   - 20-inch, 2M, AMSI 600, annular BOP

   - 20-inch pitcher nipple

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Test BOP assembly and casing to 500 psi according to instructions. Notify State official and have him witness the test. Report test on daily drilling report.

17-1/2-INCH STAGE

7. Drill out float collar and cement with 17-1/2-inch mill tooth bit and slick assembly; treat mud for cement contamination with sodium bicarbonate and soda ash. Pull out when 20 inch shoe has been drilled and run into the hole with new 17-1/2-inch bit, reamer, shock absorber, 17-1/2-inch stabilizer, and drill collars. Drill a straight hole to approximately 2,700 feet. Control lost circulation with LCM (cottonseed, mica, nut hull plug, or prepare a bentonite/diesel/cement "gunk" squeeze as follows:

-For 100 barrels batch:

1. 140 sacks bentonite

2. 70 barrels diesel

3. 140 sacks Portland cement

Blend bentonite and diesel together in pre-mix tank, mix cement last and pump immediately using truck pumps. Pump only through open-ended drill pipe.

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8. If necessary, drill ahead with lost circulation, as long as connections are easily made and small drag on the bit is detected while tripping out of the hole. Have minimum 1,500 bbls of emergency water storage on location, connected to circulation/pumping manifold. Drill well with mud. Control drift angle with stiff drilling assembly. Take a drift shot and maximum temperature measurement at casing point.

13-3/8-INCH CASING

9. At casing point, circulate hole clean and short-trip collars. Tag bottom and circulate bottoms up before tripping out for running casing. Run 2,700 feet of 13-3/8-inch, 68 lbs/ft, Grade L-80, Vallourec-VAM threaded casing. Equip casing as follows:

- 13-3/8-inch guide shoe, welded
- one joint of 13-3/8-inch casing
- 13-3/8-inch insert float valve
- One centralizer above shoe, next one on first collar, then every 90 feet (every third joint)

Based on the knowledge of the circulation losses, a 13-3/8-inch stage cementing collar should be available on site and ready to be placed in the casing. Two stage cementing shall be performed if necessary, positioning the cementing port either in correspondence

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with the more severe loss zone or directly below the 20" casing shoe. The second stage will be pumped through casing.

10. Run casing while filling each three joints. Tack-weld bottom 3 collars, use thread lock compound on first 3 collars. Circulate 200 cu.ft of water and 200 cu.ft of pre-flush ahead of cement. Cement through casing as per the Casing and Cementing Prognosis, page 22.

11. Monitor returns and prepare to run 1-inch pipe into annular space to do top-job cementing, if required. If annular cementing is required, tag top of cement and pump Class G cement blended with 40% Silica flour, 2% calcium chloride, 0.65% CFR-2. Repeat this operation until the annulus has been fully cemented.

12. Land 13-3/8-inch casing. Install 13-3/8-inch BOP assembly (see figure 4) as follows:

    - Slip-on-weld, 13-3/8 X 13-5/8-inch, 3M, ANSI Series 900, casing head, equipped with two 3-inch flanged and valved outlets

    - 13-5/8-inch, 3M, ANSI 900 double ram (pipe and blind ram) preventer

    - 13-5/8-inch, 3M, ANSI 900, annular BOP

    - Pitcher nipple

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Have certified welder to pre-heat, weld inside and outside and post heat 13-3/8-inch casing and casing head, according to API recommended procedure (API - Spec 6A). Test welds to specified pressure. Test BOP assembly and casing at 1,000 psi according to instructions. Notify State official and have him witness the test. Record test on daily drilling report.

12-1/4-INCH STAGE

13. Drill out float collar and cement with 12-1/4-inch bit and slick assembly. Treat mud with sodium bicarbonate and soda ash to control viscosity while drilling cement. Pull out when 13-3/8-inch shoe has been drilled and run into the hole with new 12-1/4-inch bit, reamer, shock absorber, 12-1/4-inch stabilizer, drill collars. Drill a straight hole to approximately 4,000 feet. Control hole deviation using a stiff bottomhole assembly. Control losses of circulation with LCM or bentonite/diesel/cement squeezing. If necessary, spot specially designed, water seeking cement plugs and squeeze them using hesitation squeeze methods. Drill well with mud to casing depth.

9-5/8-INCH CASING

14. At casing point, circulate hole clean and short-trip collars off the bottom. Tag bottom and circulate bottoms up with low viscosity mud before tripping out for running casing. Run 4,000 feet of 9-5/8-inch, 47 lbs/ft, Grade C-90, Vallourec-VAM threaded casing. Equip casing as follows:

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- 9-5/8-inch float shoe, welded (weld C-90 casing according to API Spec.5AC)

- one joint of 9-5/8-inch casing

- 9-5/8-inch super-seal float collar

- 9-5/8-inch stage cementing collar (if needed, to prevent cement loss)

- one centralizer above shoe, next one on first collar, rest of centralizers to be positioned as determined by cementing contractor

As for the 13-3/8-inch casing, depending on the occurrence of losses of circulation, a 9-5/8-inch stage cementer should be available on site and ready to be placed in the casing string. The location of the stage cementer shall be decided either according to the location of the losses of circulation or as close as possible to the 13-3/8-inch casing shoe. The second stage will be cemented through casing.

15. Run casing while filling on every third joint. Tack weld bottom three collars. Welding on C-90 casing must follow the procedure recommended in API Spec 5AC. Use thread compound on first three collars and float equipment. Circulate ahead of cement 400 cu.ft of water, followed by 200 cu.ft of pre-flush. Cement as per Casing and Cementing Prognosis, page 25.

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16. During cementing, monitor returns and prepare to run flush jointed tubing into annular space to do top-job cementing if required. If annular cementing is required, tag cement top with tubing and pump Class G cement blended with 40% silica flour, 2% calcium chloride, 0.65% CFR-2. Repeat operation as many times as necessary to fill up the annulus with cement.

17. After plug has been bumped, or after last top-job is completed, drain and wash BOP equipment, unbolt at casing head flange and install and secure casing aligning slips into casing head bowl. Wait on cement 12 hours.

18. Land 9-5/8-inch casing to specified length above the casing head. Clean and prepare casing according to instructions from manufacturer. Install 13-5/8-inch X 10-inch, 3M, expansion spool equipped with special high temperature packing sleeve.

19. Install the 8-1/2-inch BOP assembly above expansion spool (see figures 5 and 6) as follows:

    For mud drilling:

    - 10-inch, 3M, ANSI 900, gate valve

    - 10 X 13-5/8-inch, 3M, AMSI 900, cross-over spool

    - 13-5/8-inch, 3M, ANSI 900, double ram BOP (pipe and blind rams)

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- 13-5/8-inch, 3M, ANSI 900, annular BOP

- 12-inch pitcher nipple

For stiff-foam/aereated mud drilling:

- 10-inch, 3M, ANSI 900, gate valve

- 10 X 13-5/8-inch, 3N, AMSI 900, cross over spool

- 13-5/8-inch, 3M, ANSI 900, single pipe ram (solid) BOP

- 13-5/8-inch, 3M, ANSI 900, banjo box, equipped with 10-inch, 3M, AMSI 900, hydraulically activated side valve

- 13-5/8-inch, 3M, ANSI 900, double ram (pipe and blind rams) BOP

- 13-5/8-inch, 3M, ANSI 900, annular BOP

- Grant rotating/stripping head

Test BOP assembly and casing after closing 10-inch diverter valve on banjo box. Test pressure to 1,000 psi. Notify State official and have him witness the test. Record test on daily drilling report.

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8-1/2-INCH STAGE

20. Install H_2S abatement system, and muffler (see figure 7) to be used when air/foam drilling system is activated. Drill out float collar and cement with 8-1/2-inch bit and slick assembly. Treat mud with sodium bicarbonate and soda ash as required to control the viscosity. Pull out when 9-5/8-inch shoe has been drilled and run into the hole with new 8-1/2-inch bit, reamer, high temperature shock absorber, 8-1/2-inch stabilizer, drill collars. Drill a straight hole using mud until the first important loss circulation zone is encountered. At that moment, decision will be made on whether to continue drilling with water, using a slick assembly and pumping mud "pills" at every connection to displace the drill cuttings away from the bit, or to switch to aereated water or stiff foam system. If water drilling with a slick assembly is chosen, there will be less control on the hole deviation and angle drift measurements must be made at shorter intervals (see Angle Survey Program on page 30).

21. Drill well to a maximum of 7,500 feet. If no production zone is encountered to this depth, log the well and complete as an injection well, or plug and abandon. Fill hole with mud and run logs to TD as directed.

22. If the well is drilled and at some depth a commercial production zone is encountered, prepare to run the slotted liner. A constant stream (30-40 GPM) of cold water must be kept running into the well to keep it quenched.

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7-5/8-INCH SLOTTED LINER

23. Run 7-5/8-inch, Grade L-80, 42.8 lbs/ft, Hydril SFJ threaded liner, as per Slotted Liner Prognosis on page 28. Equip liner with guide shoe, weld shoe solid and tack-weld first three joints. Use thread lock compound on first three collars. Hang liner 25 feet above bottom, leaving 4 blank joints below hanger.

24. Run into the hole with enough 3-1/2-inch drill pipe to clean and displace the mud inside of the hole. Trip up and down the hole until several hole volumes of water have been pumped.

25. Trip out laying down drill pipe. Install second valve on wellhead. Conduct three step injectivity test using rig's pumps and downhole pressure monitoring tools. Close valves and allow well to warm up for a minimum period of one month. Conduct temperature/pressure surveys during warm-up period to monitor well temperature recovery and obtain information on the location of the feed zones.

<u>Drilling Fluid Program</u>

1. <u>Surface to 1,400'</u>

Use gel, water (lime base) mud with additives as necessary for viscosity control for lifting cuttings. The following properties must be maintained:

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Mud Weight: 9.1 ppg or 68 #/cu. ft.
Viscosity: 40-45 secs.
API F.L.: 10+

2. <u>1,400' to 4,000' MD</u>

Resinex may be needed to control fluid loss and act as a thinner as the temperatures increases. Use sufficient viscosity in mud to lift curings to keep the well bore clean and prevent large amounts of fill on connections. The following properties are requested.

YP - 5-10
API F.L. - 8-10 cc
Mud Weight: 9.0-9.5 ppg or 67-70#/cubic foot
Initial Gels (10 secs.) - 2-5#/100 sq. ft.

Well to be drilled with mud or foam below 9-5/8-inch casing (± 4,000 feet), where needed.

Install and operate a mud cleaner. Maintain a supply of lost circulation material on location such as cottonseed hulls and walnut hulls. Maintain a supply of weighting material (barite) on location in case needed for control of flow from well during drilling.

Use minimal amounts of non-chromium lignite, caustic soda and quebracho as needed to condition mud. Use soda ash and sodium bicarbonate for cement contamination.

3. <u>4,000' to 7,500' M.D.</u>

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Mud or stiff-foam where necessary.

Drift Angle Pleasurement Program

1. Drift angle surveys shall be made within 100 ft of all casing set points and at T.D.

2. 0 to 1,400′ - every 500′ or closer and at bit changes to monitor changes in angle or direction.

3. 1,400 to 2,700′ - every 500′ if deviation is less than 3° or every 300′ if deviation is more than 3°.

4. 4,000′ to TD - every 100 feet if a slick assembly is chosen every 500′ for a packed hole assembly.

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CASING AND CEMENTING PROGNOSIS

FOR 1 STAGE CEMENT JOB ON 1,400 FT. 20" STRING/LINER

1. Well description: Puna Well No.

2. This prognosis is based on using a 9.5 ± 0.2 ppg mud and setting casing @ 1,400 feet and/or - feet into/below surface.

3. If on reaching casing point the above conditions do not apply, or if other well circumstances make using this prognosis inadvisable, the drilling operations supervisor is to review the matter with supervision. Field personnel are encouraged to review prognosis with cementing company as early as practical.

4. Casing Program: Casing size 20". Casing to be run 1'-3' above T.D.

Make up, etc. allowance ___ ft. of ___ lbs/ft.

Surface to 1,400 ft.

Total length: 1,400 ft. of 106 lbs/ft., K-55, BTC Casing

Maximum Allowable Stresses

Tension (lbs)	Collapse (psi)	Burst (psi)
1,683,000	770	2,320

Safety Factors

3.46	1.31	1.94

(No buoyancy contemplated)

Casing weight in 9.5 ppg mud: 126,800 lbs.

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5. Casing Hardware:
Float shoe type: Weld on Guide Shoe
Float collar 1 joint(s) above shoe
Float Collar type: insert valve
Centralizers: one at and above shoe. Also, every 90 ft. (every third joint above float collar).

Estimated number of centralizers: 16. (Locate over collars.)
Scratchers every - ft. to cover - from - ft. to - ft.
DV tool located @ - ft. Type: - .
Other equipment: Pipe lock bottom two joints.

6. Preflush Water Volume: 300 cu.ft.
Other Type: Light cement preflush
Volume: 300 cu.ft.

7. Cement and Cement Volume:

First stage: Type: Class G + 3% $CaCl_2$.
Slurry weight: 16.4 ppg. Slurry yield: 1.06 ft^3/sack.
Thickening Time: 1 hr ___ Retard for ___ hours pumpability @ ___°F (BHST).
X Accelerate for 16 hours WOC time.
___ Not critical.

Friction reducer: X Establish turbulent flow @ ____ bbls/min.
___ Not critical.

Volume: Base on caliper log/experience and use sufficient to:
__ Cover ______ formation plus ______ ft.
X Circulate to surface.
__ Reach ______ ft.
Minimum volume 3,970 sacks, based on 26" hole;
+100% excess = 4,215 ft^3

Water requirement: 4.3 gal/sk

Total volume of water: 2,280 ft^3

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Casing Running and Cementing Operation:

The following special instructions are in force:

8. Reciprocation:
   _X_ Do not reciprocate.
   ___ Reciprocate until just prior to bumping plug. Do not exceed _____ lbs. additional tension from drag and cement weight.

9. Displacement:
   Displacement cement with mud @ less than 30 cu. ft./min. (plug flow).
   Rate may be exceeded while "chasing" cement. Do not exceed 400 psi while displacing and do not exceed 750 psi when bumping plug.

10. Temperature Survey:
   _X_ Run temperature survey at casing depth in any event.
   ___ Run temperature survey if LC experienced.
   ___ Do not run temperature survey.

11. Wellhead Equipment Requirements:
   Description: CSG head for 20" Hydrill (2,000 psi)

12. Special Notes: Monitor returns and maintain cement level in annular space (top job).

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CASING AND CEMENTING PROGNOSIS

FOR 1 STAGE CEMENT JOB ON 2,700 FT. 13-3/8" Intermediate STRING/LINER

1. Well description: Puna Well No.

2. This prognosis is based on using a 9.5 ± 0.2 ppg mud and setting casing @ 2,700 feet and/or - feet into/below surface.

3. If on reaching casing point the above conditions do not apply, or if other well circumstances make using this prognosis inadvisable, the drilling operations supervisor is to review the matter with supervision. Field personnel are encouraged to review prognosis with cementing company as early as practical.

4. Casing Program: Casing size 13-3/8". Casing to be run 1'-3' above T.D.

   Make up, etc. allowance ___ ft. of 68 lbs/ft.
   Surface to 2,700 ft.
   Total length: 2,700 ft. of 68 lbs/ft., L 80 - VAM Conn. (Gauge joints)

   Maximum Allowable Stresses

Tension (lbs)	Collapse (psi)	Burst (psi)
1,545,000	2,260	4,930

   Safety Factors

3.9	2.26	2.24

   (No buoyancy contemplated)

   Casing weight in 9.5 ppg mud: 156,800 lbs.

5. Casing Hardware:
   Float shoe type: Weld on Guide Shoe
   Float collar 1 joint(s) above shoe.
   Float Collar type: insert valve
   Centralizers: one above shoe and one on first collar. Also, every 90 ft. (every third joint above float collar).

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Estimated number of centralizers: 31. (Locate over collars.)
Scratchers every - ft. to cover - from - ft. to - ft.
DV tool located @ - ft. Type: -.
Other equipment: Pipe lock bottom three joints, use geothermal rated casing dope.

6. Preflush Water Volume: 200 cu.ft.
Other Type: Super Flush
Volume: 200 cu.ft.

7. Cement and Cement Volume:
- If lost circulation is a problem, change cement to spherelite blend as shown in note (12).

First stage: Type: Class "G" cement blended with Perlite 1:1 and 40% S.F. + 2% gel + 0.65% CFR-2, retard as needed
Slurry weight: 12.3 ppg. Slurry yield: 2.65 ft^3/sack.
Thickening Time: X Retard for 4 hours pumpability @ 350 °F (BHST).
___ Accelerate for ______ hours WOC time.
___ Not critical. ___________ bbls/min.

Friction reducer: X Establish turbulent flow @ 30 cu. ft./min.
___ Not critical.

Volume: Base on caliper log/experience and use sufficient to:
___ Cover ______ formation plus ______ ft.
X Circulate to surface.
___ Reach ______ ft.
Minimum volume 1,740 sacks, based on 17-1/2" hole and 100% excess = 4,613 ft^3
Water requirement: 12.1 gal/sk
Total volume of water: 2,814 ft^3

Tail Cement: Follow with a tail volume, enough to cover bottom 200 feet of casing
Type: Class "G" cement blended with 40% silica flour and 0.65% CFR-2
Slurry weight: 15.5 ppg. Slurry yield: 1.62 ft^3/sk
Volume: Minimum volume: 164 ft^3 or 101 sacks
Water requirement: 6.8 gal/sk
Total volume of water: 90 ft^3

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Casing Running and Cementing Operation:

The following special instructions are in force:

8. Reciprocation:
 _X_ Do not reciprocate.
 ___ Reciprocate until just prior to bumping plug. Do not exceed _____ lbs. additional tension from drag and cement weight.

9. Displacement:
 Displace cement with water @ 10 bbls/min. (plug flow). Rate may be exceeded while "chasing" cement. Do not exceed 1,000 psi while displacing and do not exceed 1,500 psi when bumping plug.

10. Temperature Survey:
 _X_ Run temperature survey before setting casing in any event.
 ___ Run temperature survey if LC experienced.
 ___ Do not run temperature survey.

11. Wellhead Equipment Requirements:
 Description: Use continuous circulation head loaded with top plug.

12. Special Notes: (1) If lost circulation becomes a problem, spherelite cement should be blended as follows: Class "G" cement blended with 40% silica flour, 50 lbs. per sack of cement of spherelite, 4% gel, 5% lime, 1.25% CFR-2 and 0.5% Halad-22A; cement should be mixed at 82.2#/cft (11 ppg); slurry yield is 3.21 cu.ft./sack; mixing water requirements are 1.50 cu.ft./sack (11.22 gal/sack).
 (2) Monitor returns and maintain cement level in annular space.

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CASING AND CEMENTING PROGNOSIS

FOR 1 STAGE CEMENT JOB ON 4,000 FT. 9-5/8" STRING/LINER

1. Well description: Puna Well No.

2. This prognosis is based on using a 9.5 ± 0.2 ppg mud and setting casing @ 4,000 feet and/or - feet into/below .

3. If on reaching casing point the above conditions do not apply, or if other well circumstances make using this prognosis inadvisable, the drilling operations supervisor is to review the matter with supervision. Field personnel are encouraged to review prognosis with cementing company as early as practical.

4. Casing Program: Casing size 9-5/8". Casing to be run 1'-3' above T.D.

   Make up, etc. allowance: 40 ft. of 47 lbs/ft.
   Surface to 4,000 ft.
   Total length: 4,040 ft. of 47 lbs/ft., C-90 - VAM Conn. (Gauge joints)

   Maximum Allowable Stresses

Tension (lbs)	Collapse (psi)	Burst (psi)
1,210,000	4,990	7,720

   Safety Factors

Tension	Collapse	Burst
3.19	3.35	2.4

   Casing weight in 9.5 ppg mud: 162,250 lbs.

5. Casing Hardware:
   Float shoe type: Halliburton Super Seal .
   Float collar 1 joint(s) above shoe.
   Float Collar type: Halliburton Super Seal .
   Centralizers: one above shoe and one on first collar. Also, every 90 ft. (every third joint above float collar).

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Estimated number of centralizers: 45. (Locate over collars.)
Scratchers every - ft. to cover - from - ft. to - ft.
DV tool located @ - ft. Type: -.
Other equipment: (1) Pipe lock bottom three joints, use geothermal rated casing dope. (2) Use two-stage cemneting collar.

6. Preflush Water Volume: 400 cu.ft.
Other Type: Super Flush
Volume: 200 cu.ft.

7. Cement and Cement Volume:
- If lost circulation is a problem, change cement to spherelite blend as shown in note (12).

Single stage: (volumes assume one stage cementing job)
Type: Class "G" cement blended with Perlite 1:1 and 40% S.F. + 2% gel + 0.65% CFR-2, retard as needed.

Slurry weight: 12.3 ppg. Slurry yield: 2.65 ft^3/sack.
Thickening Time: X Retard for 4 hours pumpability @ 350 °F (BHST).
___ Accelerate for ___ hours WOC time.
___ Not critical. ___ bbls/min.

Friction reducer: X Establish turbulent flow @ 30 cu. ft./min.
___ Not critical.

Volume: Base on caliper log/experience and use sufficient to:
___ Cover ___ formation plus ___ ft.
X Circulate to surface.
___ Reach ___ ft.
Minimum volume 1,240 sacks, based on 12-1/4" hole and 100% excess = 3,288 ft^3

Water requirement: 12.1 gal/sk
Total volume of water: 2,000 ft^3

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Second stage (to be used only if needed); please see note (3).

(Volumes assume stage cementing collar located at +2,000 ft.):

Type: Class "G" + 40% S.F. + 0.4% HR-7 + 0.65% CFR-2.

Slurry weight: 15.5 ppg. Slurry yield: 1.62 ft^3/sack.
Thickening Time: _X_ Retard for _4_ hours pumpability @ _350_ °F (BHST).
___ Accelerate for ______ hours WOC time.
___ Not critical. ____________ bbls/min.

Friction reducer: _X_ Establish turbulent flow @ ____ bbls/min.
___ Not critical.

Volume: Base on caliper log/experience and use sufficient to:
___ Cover ______ formation plus ______ ft.
_X_ Circulate to surface.
___ Reach ______ ft.
Minimum volume 1,012 sacks, based on 12-1/4" hole and 9-5/8" casing + 100% excess = 1,640 ft^3

Water requirement: 6.8 gal/sk
Total volume of water: 920 ft^3

Casing Running and Cementing Operation:

The following special instructions are in force:

8. Reciprocation:
_X_ Do not reciprocate.
___ Reciprocate until just prior to bumping plug. Do not exceed _____ lbs. additional tension from drag and cement weight.

9. Displacement:
Displace cement with water @ 10 bbls/min. (Laminar flow).
Rate may be exceeded while "chasing" cement. Do not exceed 1,000 psi while displacing and do not exceed 1,500 psi when bumping plug.

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10. Temperature Survey:
 X Run temperature survey in any event before setting casing.
 ___ Run temperature survey if LC experienced.
 ___ Do not run temperature survey.

11. Wellhead Equipment Requirements:
Description: Use continuous circulation head loaded with top plug.

12. Special Notes: (1) If lost circulation becomes a problem, spherelite cement should be blended as follows: Class "G" cement blended with 40% silica flour, 50 lbs. per sack of cement of spherelite, 4% gel, 5% lime, 1.25% CFR-2 and 0.5% Halad-22A; cement should be mixed at 82.2#/cft (11 ppg); slurry yield is 3.21 cu.ft./sack; mixing water requirements are 1.50 cu.ft./sack (11.22 gal/sack).

(2) Monitor returns and maintain cement level in annular space.

(3) Use of a two-stage cementing collar will be decided depending upon the geological conditions encountered and the depth at which the casing will be cemented.

(4) If two-stage cementing is decided on, volume of the first stage may be calculated by simple subtraction of the volume for the second stage from the one for the single stage.

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SLOTTED LINER PROGNOSIS

FOR LINER HANGING AT 3,900 FT STRING/LINER

1. Well description: Puna Well No.

2. This prognosis is based on using water and setting liner @ 3,900 feet and/or 100 feet into/below 9-5/8" casing.

3. If on reaching casing point the above conditions do not apply, or if other well circumstances make using this prognosis inadvisable, the drilling operations supervisor is to review the matter with supervision.

4. Liner Program:
   Liner size 7-5/8".
   Liner to be run 25' above T.D.

   Make up, etc., allowance: 40 ft. of 42.8 lbs/ft.
   Total Length: 3,900 feet to 7,475 ft.: 3,615 ft. of 42.8 lbs/ft.
   L-80 Hydril SFJC

   Maximum Allowable Stress

   Tension: 998,000 lbs.

   Safety Factor

   6.5

   Liner wt. in water: 132,200 lbs.

5. Casing Hardware: Float shoe type: Guide shoe (bullnose).
   Other equipment: Pipe lock bottom joint.

6. Slotting: 2-1/2 x 1/4-inch slots, 18 rows of slots around the casing, 36 slots per foot.

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CASING PROGRAM

SIZE	INTERVAL (TVD)	LENGTH	DESCRIPTION	MAXIMUM ALLOWABLE STRESSES (SAFETY FACTOR) TENSION (lbs x 1,000)	COLLAPSE (psi)	BURST (psi)
20"	SURF-1,400′	1,400′	106#/ft K-55 BTC	1,683 (3.4)	770 (1.3)	2,320 (1.94)
13-3/8"	SURF-2,700′	2,700′	68#/ft L-80 VAM	1,545 (3.9)	2,260 (2.3)	4,930 (2.2)
9-5/8"	SURF-4,000′	4,040′	47#/ft C-90 VAM	1,210 (3.1)	4,990 (3.4)	7,720 (2.4)
7-5/8" (Liner)	3,900-TD	3,615′	42.8#/ft L-80 Hydr. SFJC	998 (6.5)	--	--

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DRILLING NOTES

1. Take drift shots as directed and/or at bit change trips. If angle persists above 5°, except in a planned directional hole, run a multi-shot survey at T.D.
2. Take maximum reading thermometer bottom-hole temperature and drift shot at bit changes.
3. Take continuous temperature profiles before setting casing strings.
4. Hold BOP practice drills once a week, each crew.
5. Check BOP closing system each trip.
6. Have flow control valve on rig floor to fit any pipe in the hole.
7. Run drill string float always.
8. Have water lines available to spray and cool well head equipment.
9. Use only high temperature rubber elements.
10. Keep mud pumps hooked up and ready when drilling with air.
11. Keep float spare on rig floor.
12. Install Geyser's type muffler-atmospheric separator system when drilling with air (see figure 7). Alternatively, construct and use rock muffler when lithology and State permits allow.
13. Install mud cooling system when needed.
14. Maintain pit level indicator with alarm.
15. When drilling with mud, wipe hole every 6-8 hours of drilling. Log string load each tour (up, down, rotating). Log 30 SPM pump pressure each tour.

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MINIMUM RIG SPECIFICATIONS

DRAWWORKS	Diesel or diesel electric, 500 HP. Rated for 8,000′ with 4-1/2" drillpipe.
MAST	Triple. Rated for 550,000 pounds, gross nominal capacity. 450,000 pounds, hook load with 8 lines.
MUD PUMPS	Main pump, 500 HP. Tail driven or independent drive. 2nd pump, 500 HP, independent drive.
LIGHT PLANT	100 KW available.
BLOCKS, ETC.	Rated 220 ton.
TABLE	27-1/2"
CIRC. SYSTEM	Two shakers, 500 bbl. system with 500 bbl. storage.
SUB BASE	22′
DRILL PIPE	7,000′, 4-1/2", 16.6#, grade E
DRILL COLLARS	2 - 10"; 12 - 6"
WATER STORAGE	2,000 bbls.
SAND LINE	7,000′

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GENERAL SPECIFICATIONS

Pipe and BOP Inspection

The initial acceptance of drill pipe should be based on an AAODC-API Class II specification inspection. All subsequent inspections should discard pipe with 30% wear or greater; i.e. use 30% where Class II states 20%.

The drill pipe inspection should include:

1. Electromagnetic inspection of tubes (Sonoscope or Scanalong).
2. Wall thickness and cross-sectional area (ultrasonic or gamma ray).
3. End area inspection (electronic or magnetic particle).
4. Tool joint O.D. caliper 5-1/4-inch min. O.D. for 4-1/2-inch XH, whichever comes first.

All drill collar end area should be magnetic particle inspected every 14 days. Every 9 days in steam.

All BOPs should be inspected for wear by the manufacturer prior to installation. All BOPs should be tested after installation prior to drilling out cement, and should be worked daily.

Remind service companies furnishing bottom-hole assemblies that their equipment should be Magna-fluxed prior to delivery.

Auxiliary Equipment

1. Five pen drilling recorder with: (a) weight, (b) rotary speed, (c) torque, (d) rate of penetration, (e) inlet pump pressure.
2. Pit level indicators and pump stroke counters.
3. Use square kelly with above (see Pipe and BOP Inspection).
4. Use tong torque assembly for making up collars.

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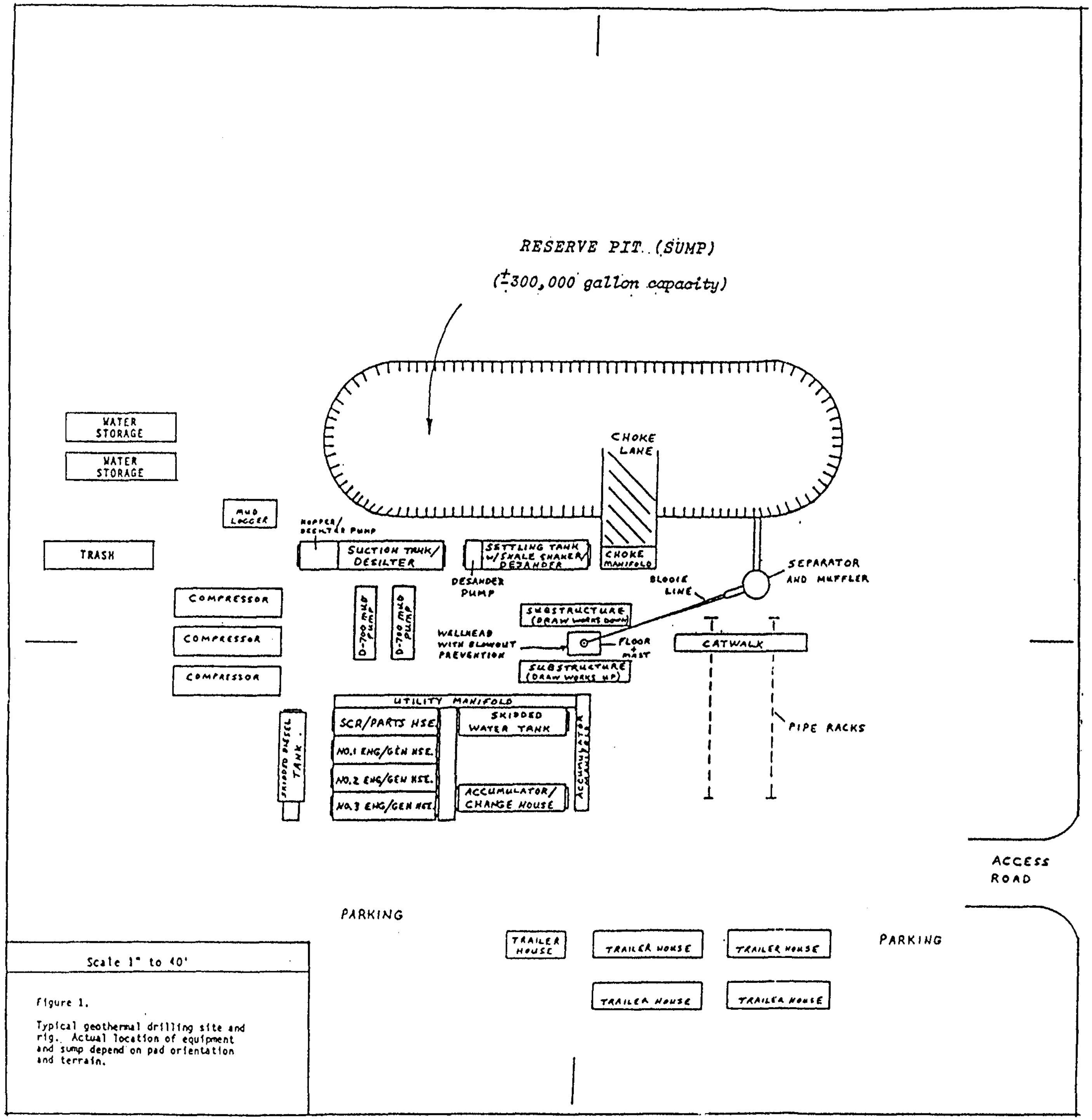
FIGURES



Scale 1" to 40'

Figure 1.

Typical geothermal drilling site and rig. Actual location of equipment and sump depend on pad orientation and terrain.

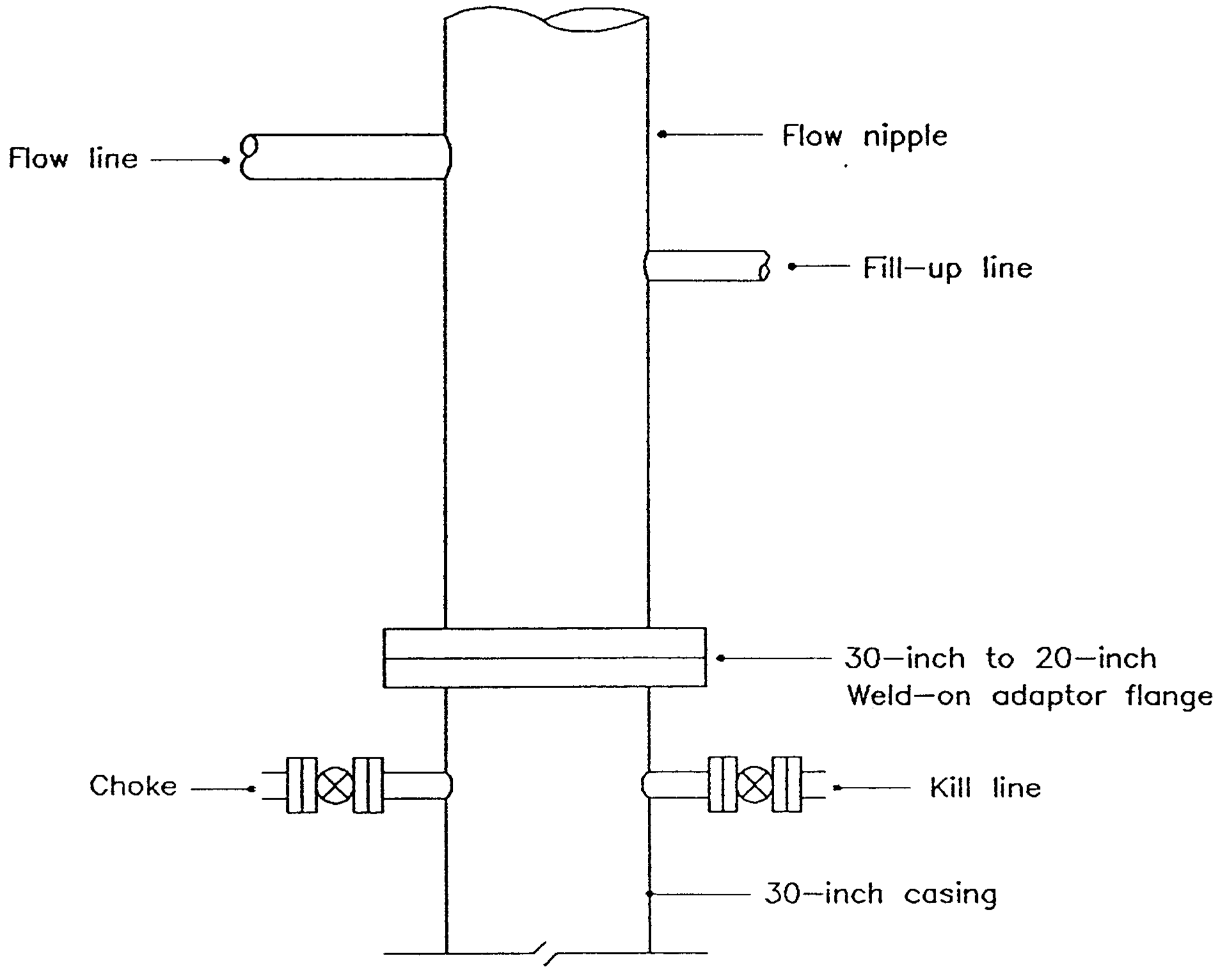


Figure 2: BOP for use on 30—inch casing string, mud drilling to ± 300′.

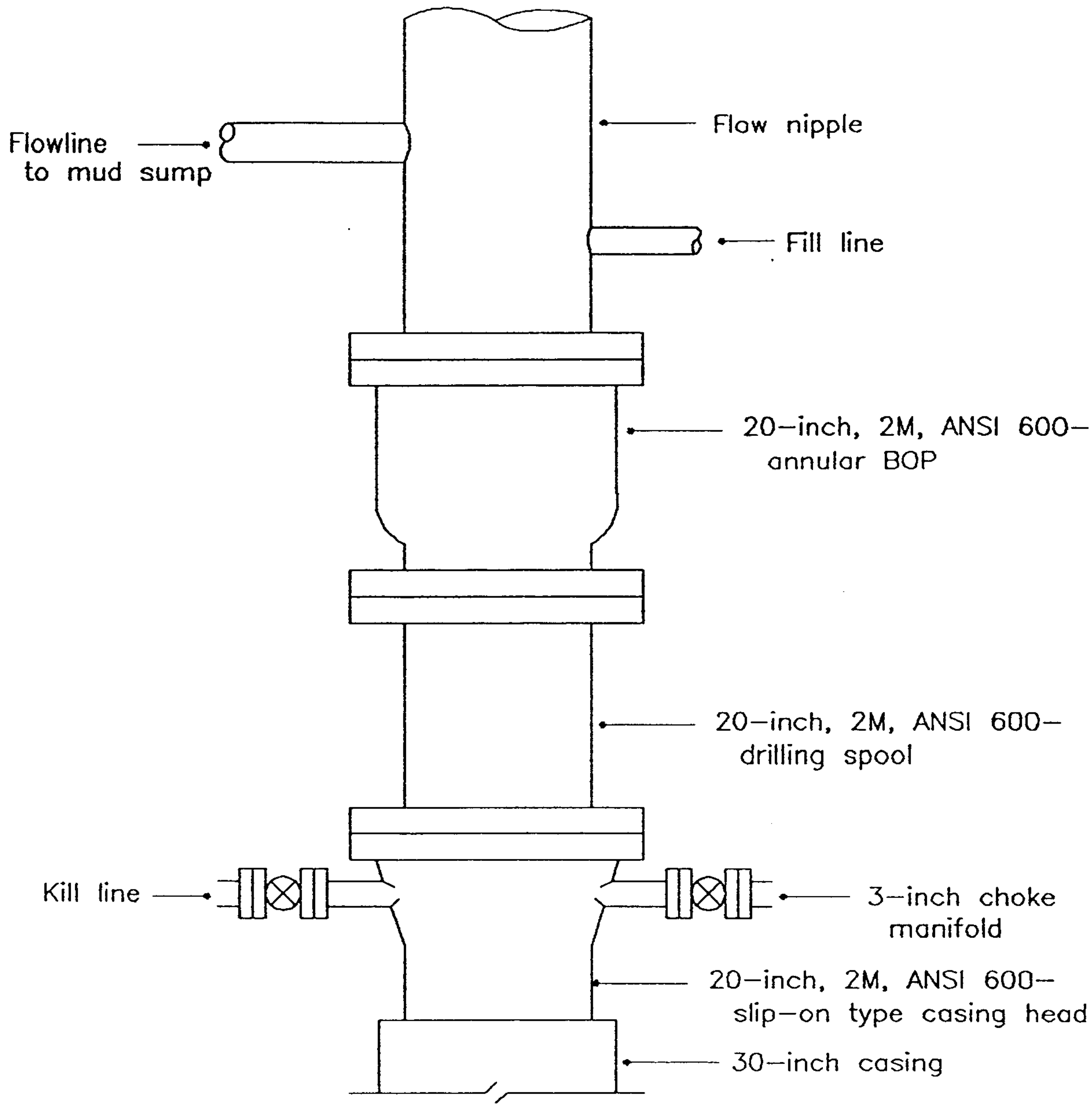


Figure 3: BOP for use on 20–inch casing string, mud drilling below ±1,400′.

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EWPUNA3/022190/H2436

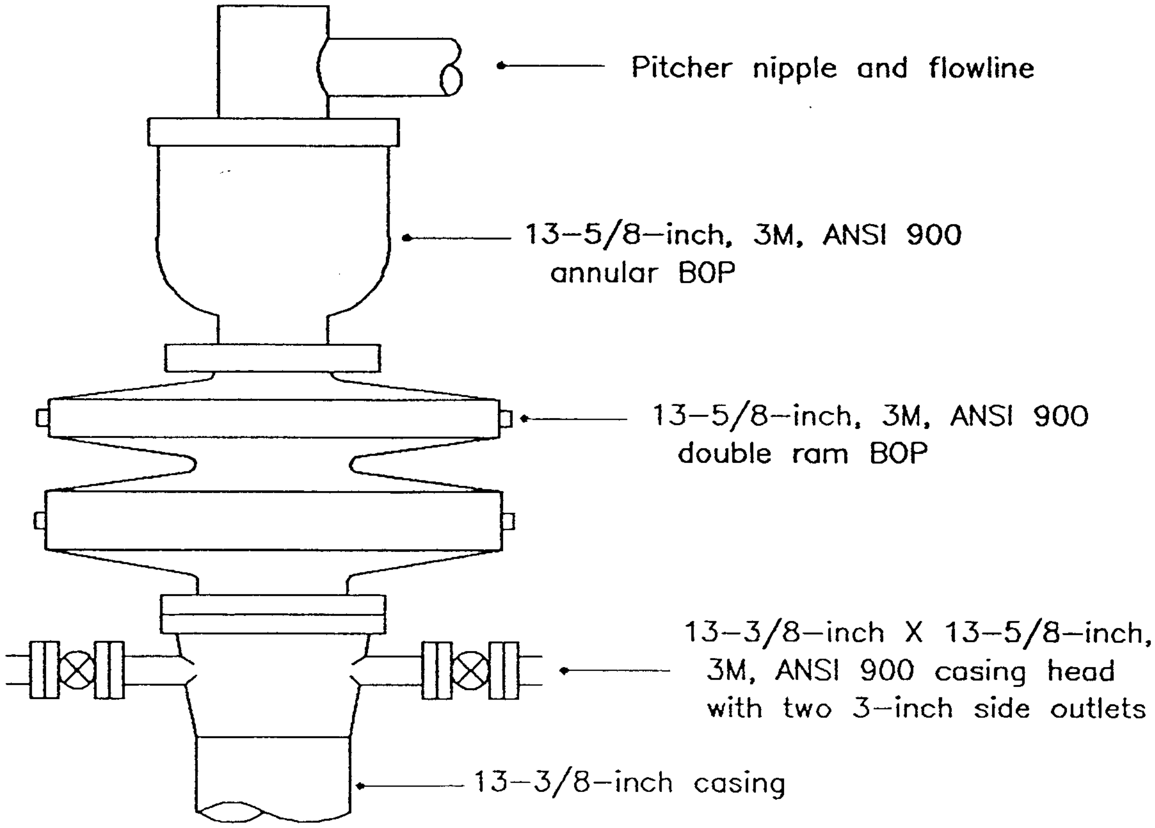

Figure 4: BOP for use on 13-3/8-inch casing string - mud drilling below 2,700'.

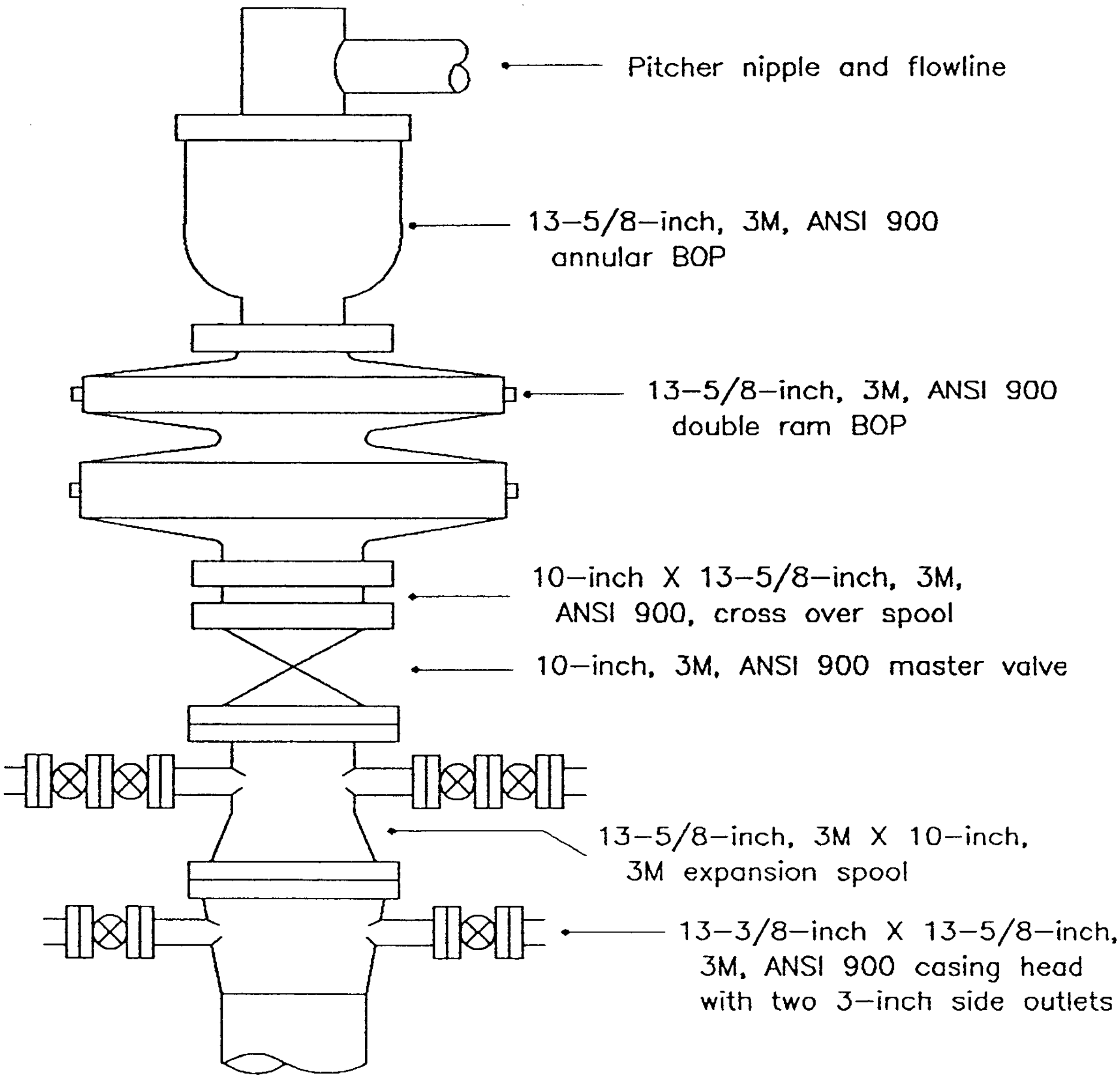

Figure 5: BOP for use on 13-3/8-inch casing string - mud drilling below 4,000'.

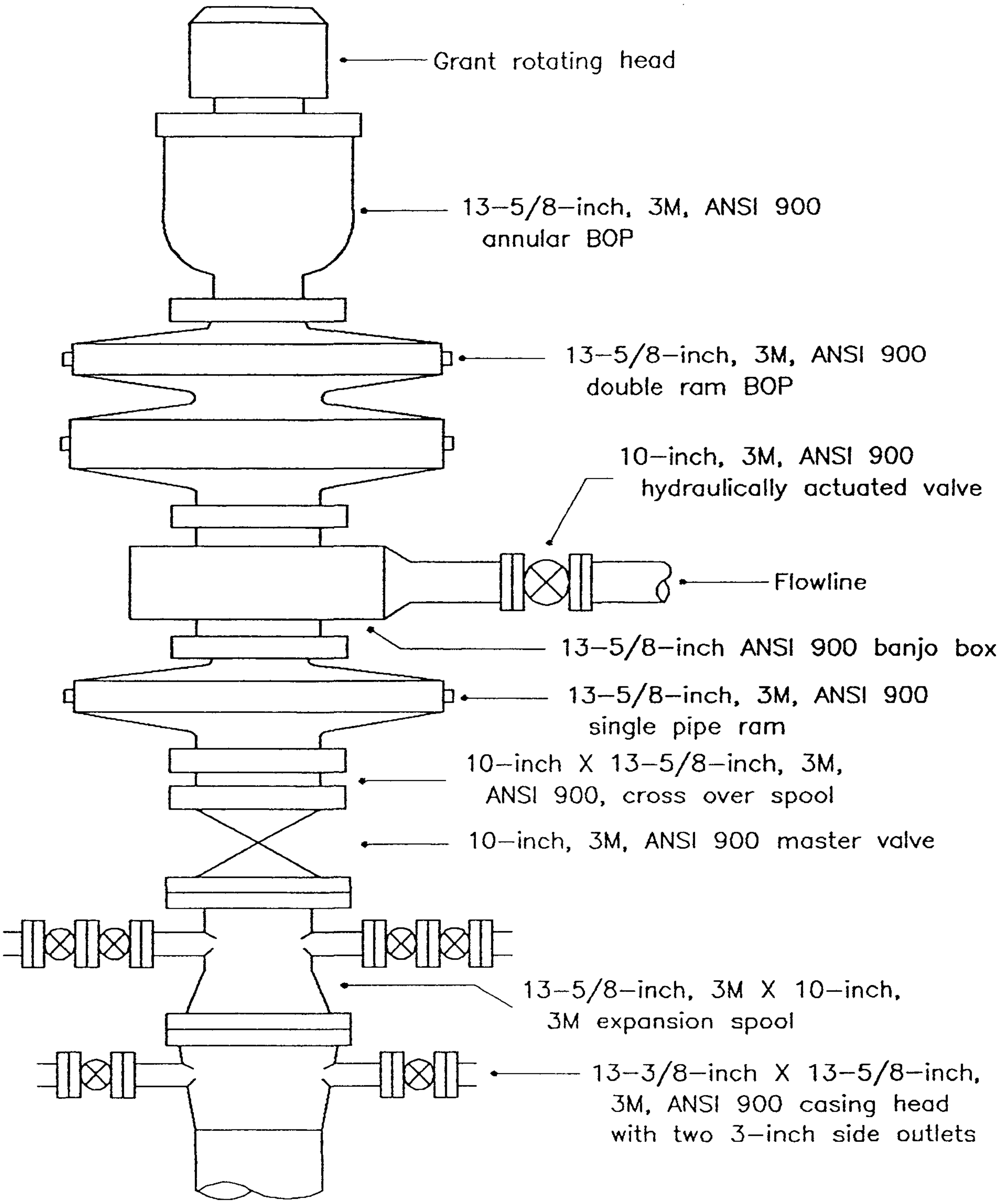

Figure 6: BOP for use on 13-3/8-inch casing string - air drilling below 4,000'.

FIGURE 7.

DRILLING WORKSHEET

TITLE: PUNA K.G.R.A.

WELLS:

LOCATION:

OBJECTIVE: Drill a water-steam producer to 7,500'

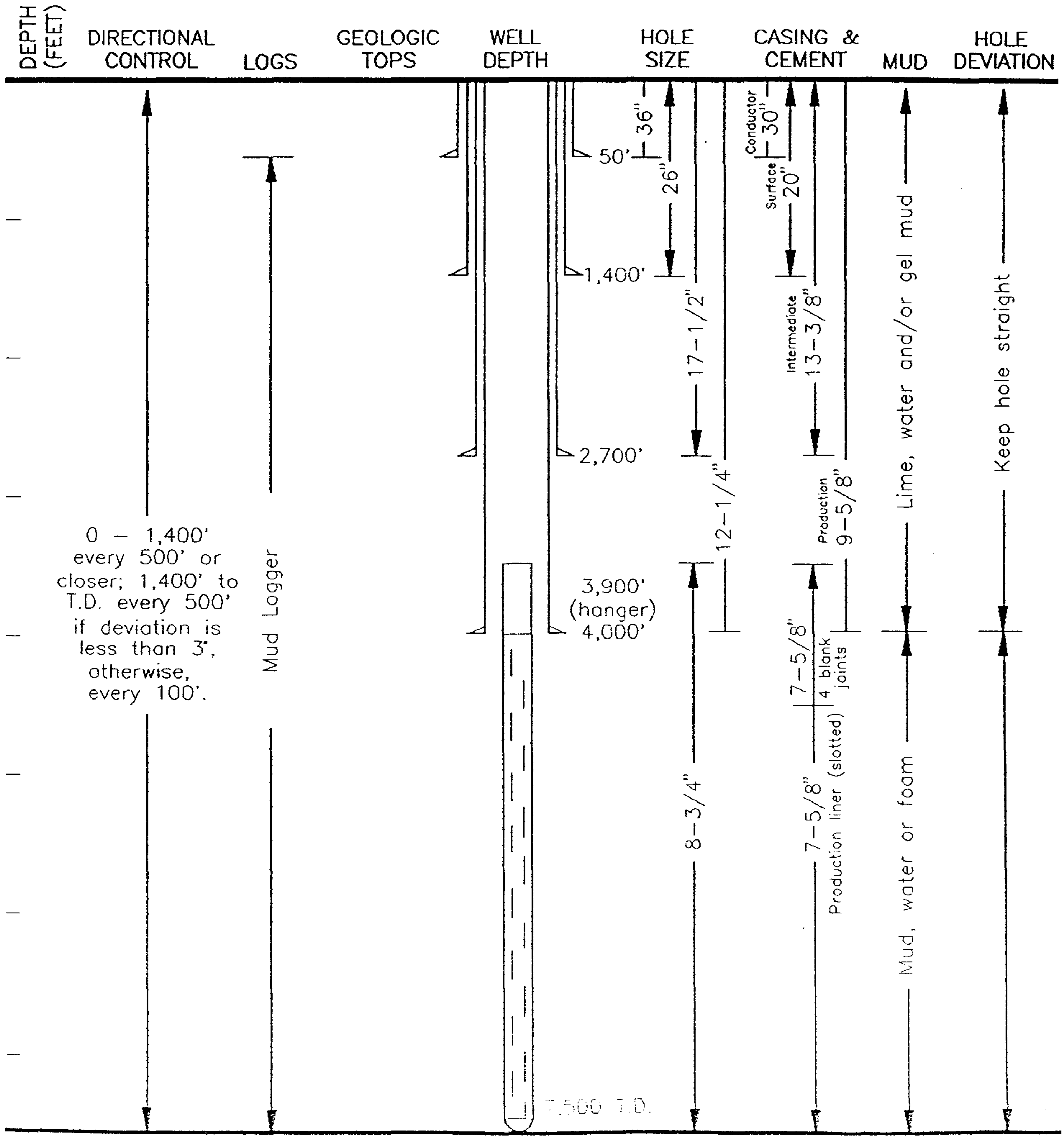

FIGURE 8, SILENCER-MUFFLER TO BE FURNISHED WITH SUBSEQUENT DRAFT.

PUNA WELL TESTING PROGRAM

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PUNA WELL TESTING PROGRAM

OBJECTIVE: The objective of the three week production test is to determine the well productivity, enthalpy and chemical nature of the fluids produced by the well.

The following reservoir characteristics will be determined from the test:

- The location and nature of the main feed zones.
- The downhole temperature and pressure characteristics of the well.
- The near-wellbore hydraulic parameters (skin, flow capacity).
- The enthalpy of the produced fluids.
- The chemistry of the produced fluids.
- The initial power potential of the well.

TEST DESCRIPTION:

The test program will be implemented after the well has completed its warm-up period. It is recommended that immediately after drilling has been completed, a short-injection/pressure falloff test (lasting less than 1 day), using the rig pumps, be conducted. The data obtained from this short test will be compared with the results of the long-term flow test.

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The flow test will be run at one single rate for a period of time long enough to allow the well to reach near-stable conditions. A period of about three weeks of flow time has been recommended. Flow parameters will be monitored manually or automatically recorded on an hourly basis. The flow will be diverted from the well through a horizontal flow line equipped with sampling and metering ports, and a James tube. The fluid will be directed to an atmospheric muffler/separator; the liquid phase will be diverted and measured by means of a weir box, and the steam will be collected and chemically treated to abate the H_2S prior to its venting into the atmosphere.

Chemical samples of both gases and liquid will be obtained, using a micro-separator, on a scheduled basis. Temperature/pressure/spinner surveys using mechanical tools will be run at static conditions prior to initiating the flow, and under flowing conditions during the flow period. At the end of the test, a pressure build up survey will be run when the well is shut-in.

TEST PROCEDURE:

1. While the well heats up after drilling, temperature and pressure surveys should be conducted to obtain information on the well feed zones and their temperature. A small bleed should be initiated through one of the side valves of the expansion spool a few days before the well is discharged, to heat up the casing.

2. Install the flow line equipment, instrumentation and abatement system. Install a blind flange at the end of the flow test facility and test hydrostatically to 300 psi.

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3. Open the well vertically for cleanout, and flow through a 6-inch discharge pipe for a short period of time (not to exceed two hours). Monitor wellhead pressure and discharge lip pressure.

4. Divert the discharge to the separator and start operation of the abatement system. Open well to full flow. Monitor on an hourly basis the following parameters: wellhead pressure, wellhead temperature, flow line pressure and temperature, pressure differential across the orifice, discharge lip pressure and weir box level.

5. Collect steam/water/gas samples on the first and second days and every other day thereafter, or as specified by the testing engineer.

6. Run flowing temperature/pressure/spinner surveys at least two times spaced throughout the test. Conditions encountered during the test may indicate the requirement for extra runs.

7. At the end of the flowing period, run two pressure tools and one temperature tool in the well. Locate tools opposite the level of the most important fluid entry zone, determined from the previous flowing and static surveys. Shut the well in and monitor the pressure build up for a six hour period. Retrieve the tools and have them interpreted at the site. Depending on the results of the first survey, a decision will be made on whether it is necessary to run a second set of tools for another period of 6 hours.

8. Run static pressure/temperature/spinner surveys at 2 and 5 days after shut-in, and as needed thereafter.

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REPORTING:

The test data will be transmitted to GeothermEx's home office for inspection and quality assurance on a daily basis. Changes to the test program will be introduced as needed. A test report will be submitted, including a comprehensive description of the test activities and data collected, and the interpretation of the results.

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Short Term Production Testing
Equipment Specifications and Cost Estimates

Project: Barnwell - Production Well Testing
Attn: Dr. Martin Jokl
Date: January 15, 1990

1. Flow Rate Metering System

A. Piping: 10-inch diameter, schedule 40 flow line, equipped with ANSI-300 flanged connections and a 10-inch ANSI-600 gate valve. The flow line to be fabricated by Barnwell according to specifications, including metering/sampling ports and 3 James Tube diameters (1).

$12,000.00

B. Atmospheric Separator/Muffler: Fabricated by Barnwell according to specifications, of 1/2-inch thick rolled steel plate. The separator shall be designed for a working pressure of 15 psig for a well of 5 MW maximum size (1).

$8,000.00

C. Weir Box: Fabricated by Barnwell according to specifications, of 1/4-inch steel plate (1).

$5,000.00

Sub Total, metering system $25,000.00

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2. Flow Metering Instrumentation

A. Pressure Metering

5 inch dial pressure gauges procured by GeothermEx, equipped with diaphragm sealed sensor system. Ranges: 0-50 (2 units), 0-200 (3 units), 0-600 (2 units) [1].

$2,500.00

B. Differential Pressure Metering

2 pen differential and static pressure recorder procured by GeothermEx, equipped with liquid filled (bellows) sealed sensor system (1 unit) [1].

$2,000.00

C. Temperature Metering

Temperature indicating transmitter procured by GeothermEx, with type "J" thermocouple (0-600°F) for field mounting configuration (3 units) [1].

$750.00

D. Orifice Plates

10-inch paddle type orifice plates procured by GeothermEx, 1/8 inch thick SS-316 with calculations for 0-680 inches W.C., 40% steam, 80% brine (3 units) [1].

$700.00

Sub Total, Instrumentation $5,950.00

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3. Chemical Sampling

A.	Mini-separator, rental from GeothermEx, $100/day.	$3,000.00
B.	Sampling flasks, reagents, vials, laboratory analyses.	$4,000.00
	Sub Total, Geochemistry	$7,000.00

4. Downhole Metering System:

Option I: Purchase Equipment (Kuster Tools)

A. High temperature: downhole temperature pressure gauges and KPG type recorder (2 of each type); high performance 6 hour clocks (2 extra), sinker bars, KTG & KPG spare parts, repair kits, ultrasonic cleaning kit, field chart reader (1).

$21,500.00

B. Wireline Mechanical Hoist
Barnwell may use either option of stainless wireline per cost, or own 1/2-inch sand line hoist).

$11,700.00

Option I, Sub Total, Pressure metering $33,200.00

Option II: Equipment rental and wireline logging services

Contract logging services as needed from Pruett or alternative:

A. Skid Hoisting Unit (each 30 days on location) $1,000.00

GeothermEx, Inc.
SUITE 201
5221 CENTRAL AVENUE
RICHMOND, CALIFORNIA 94804-5829
(415) 527-9876
CABLE ADDRESS GEOTHERMEX
TELEX 709152 STEAM UD
FAX (415) 527-8164

B.	Instrument charges, @ $500/run, 6 runs	$3,000.00
C.	Labor @ $300/day (excluding per Diem and Travel)	$3,000.00
D.	Transportation (Equipment only)	$6,000.00
E.	Travel, personnel	$1,500.00
F.	Expenses, personnel @ $100/day/person	$1,000.00
	Option II, Sub Total, Pressure metering	$15,500.00

5. Professional Services, GeothermEx, Inc.[2]

A. Well Test Engineer: preparation, field services, report preparation (55 days @ $520) — $28,600.00

B. Geochemist: preparation, field service, reporting (15 days @ $520) — $7,800.00

C. Travel: 3 trips @ $500/round trip — $1,500.00

D. Subsistence: Hotel, meals, car rental 40 days @ $125.00 — $5,000.00

E. Communications: shipping, reproduction, etc. — $1,000.00

F. Secretarial services: 10 days @ $300/day — $3,000.00

Sub Total, Professional Services — $46,900.00

6. H_2S Abatement System

Contract abatement services as needed:

A. Abatement Unit (30 days on location, transportation included) — $27,000.00

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B.	Manpower (two men, excluding per Diem and Travel Costs)	\$4,000.00
C.	Travel	\$1,000.00
D.	Expenses	\$6,000.00
E.	Chemicals (21 days x \$2,500/day, transportation included)	\$52,500.00
	Sub Total, Abatement	\$90,500.00

Total Costs, Flow Test

Expense Item	Option A	Option B
1. Flow Metering System	25,000	25,000
2. Flow Metering Instrum.	5,950	5,950
3. Geochemical System	7,000	7,000
4. Downhole Metering:		
Purchase	33,200	-
Rent	-	15,500
5. Professional services	46,900	46,900
6. H_2S Abatement System	90,500	90,500
Total	208,550	190,850

Notes: (1) These items are also used during a long-term test. The atmospheric separator/muffler used during the short-term test helps to determine the engineering design of the pressure separator. The atmospheric separator/muffler will also be required during a long-term test that uses a pressure separator. Fluids

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leaving the pressure separator still contain some steam; also, for confirmation by James tube - weir box measurements the atmospheric separator is required.

(2) Costs for GeothermEx assume that Barnwell dedicates the full time of Dr. M. Jokl during the field tests. If this is not a correct assumption, then add:

A.	Assistant Test Engineer: field services, report preparation, 35 days @ $400	$14,000.00
B.	Travel	$500.00
C.	Subsistence: 30 days @ $100.00	$3,000.00
	Sub Total	$17,500.00

JOHN WAIHEE
GOVERNOR OF HAWAII

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES

JOHN P. KEPPELER, II
DONA L. HANAIKE

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STATE PARKS
WATER AND LAND DEVELOPMENT

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF WATER AND LAND DEVELOPMENT
P. O. BOX 373
HONOLULU, HAWAII 96809

August 25, 1992

Mr. Martin L. Jokl, President
Barnwell Geothermal Corporation
2828 Paa Street, Suite 2085
Honolulu, HaWAII 96819

Dear Mr. Jokl:

Thank you for your May 8, 1992 letter which was faxed to us on July 8, 1992, informing us of your additional steps to assure the location of the bottom-most plug. We have no objections to your plans to use a wire line logging unit to set a bridge plug at 4,053 feet, place a few feet of sand and gravel on top of the bridge plug, then use tubing to place the 250-foot cement plug just above the sand and gravel.

Please be advised, however, that Barnwell Geothermal Corporation will still need to verify the location and depth of the cement plug.

Please notify us of the proposed start and end date of abandonment activities and at least 48 hours prior to actual start of the abandonment activities.

Should you have any questions on this matter, please feel free to contact Gordon Akita at 587-0227.

Sincerely,

MANABU TAGOMORI
Manager-Chief Engineer

BARNWELL INDUSTRIES, INC.

TELECOPIER COVER LETTER

TO:	MANABU TAGOMORI
COMPANY:	Department of Land & Natural Resources/Division of Water and Land Development
TELECOPIER NUMBER:	587-0219
FROM:	Martin L. Jokl / Renee L. Zubek
DATE:	7/8/92
NUMBER OF PAGES TO FOLLOW THIS COVER SHEET:	1

MESSAGE: RE: PLUGGING AND ABANDONMENT OF ASHIDA GEOTHERMAL TEST HOLE

Dear Mr. Tagomori:

Following, for your convenience, is a copy of Mr. Jokl's letter to you dated May 8, 1992.

Renee L. Zubek

If any of these pages are not properly received, please contact our office at (808) 836-0136 immediately.
Our telecopier is a Cannon 850, Telecopier number (808) 833-5577.

2828 Paa Street • Suite 2085 • Honolulu, Hawaii 96819 • Telephone (808) 836-0136 • Telecopier (808) 833-5577 • Telex 7238672 WRII HR

BARNWELL GEOTHERMAL CORPORATION

May 8, 1992

Mr. Manabu Tagomori
Manager & Chief Engineer
State of Hawaii
Department of Land & Natural Resources
Division of Water & Land Development
P.O. Box 373
Honolulu, Hawaii 96809

Dear Mr. Tagomori:

Barnwell Geothermal Corporation ("BGC") has been working to finalize the details for the abandonment of the Ashida #1 well. After consultation with several vendors, we feel it would be prudent to take additional steps to assure the location of the bottom most cement plug. In particular, we would like to add the following step to the plugging plan:

1. Use a wire line logging unit to set a bridge plug at a depth of 4,053 feet. This is the depth of the bottom of the deepest cement plug as set forth in the original plan. A few feet of gravel and sand will be placed on top of the plug, and then about two feet of cement will be placed onto the sand. This will produce a firm base for the 250' cement plug, guaranteeing the location of the plug.

2. Lower tubing to a depth just above the plug and pump the 250 foot cement plug through the tubing further assuring the accurate placement of the plug.

We contemplate no other changes in the plan. The above modifications will provide a more reliable placement of the bottom plug.

We hope to be prepared to commence plugging operations towards the end of may, and I look forward to you comments on these changes.

Sincerely,

Martin L. Jokl
President

MLJ/rz

2828 PAA STREET, SUITE 2085 • HONOLULU, HAWAII 96819 • TELEPHONE (808) 839-7720 • TELEX 723-8672 • TELECOPIER (808) 833-5577

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT
P. O. BOX 621
HONOLULU, HAWAII 96809

JAN 22 1992

REF:WRM-KY

Mr. Martin L. Jokl, President
Barnwell Geothermal Corporation
2828 Paa Street, Suite 2085
Honolulu, Hawaii 96819

Dear Mr. Jokl:

Responding to your letter of January 3, 1992, this Department has no objection to granting you a one-year extension to your permit of February 13, 1991, to plug and abandon the Ashida Geothermal test well.

Accordingly, your permit to plug and abandon the Ashida Geothermal test well is hereby amended to be in effect through February 12, 199~~2~~3.

Very truly yours,

WILLIAM W. PATY
Chairperson

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT
P. O. BOX 621
HONOLULU, HAWAII 96809

JAN 31 1992

Mr. Martin L. Jokl, President
Barnwell Geothermal Corporation
2828 Paa Street, Suite 2085
Honolulu, Hawaii 96819

Dear Mr. Jokl:

Our letter to you dated January 22, 1992 contained an error. The letter should have read "...your permit extension is hereby amended to be in effect through February 12, 1993."

I hope this error did not cause you any inconvenience.

Very truly yours,

MANABU TAGOMORI
Deputy Director

JS:ky

BARNWELL GEOTHERMAL CORPORATION

January 3, 1992

RECEIVED
92 JAN 6 AM 11:48
DIV. OF WATER &
LAND DEVELOPMENT

Mr. William W. Paty
Chairperson
Board of Land and Natural Resources
State of Hawaii
Department of Land and Natural Resources
P. O. BOX 621
Honolulu, HI 96809

RE: PLUGGING AND ABANDONMENT OF ASHIDA TEST WELL NO. 1

Dear Mr. Paty:

On February 13, 1991 the Department of Land and Natural Resources issued a permit on Well No. 1 to Barnwell Geothermal Company to plug and abandon the Ashida Geothermal test well.

Barnwell has recently received a letter from the landowner granting us permission to abandon the site as proposed in the abandonment plan. That letter has been submitted to your Department.

We are moving to finalizing our plugging and abandonment schedule, but are concerned that we will be unable to mobilize before the plugging and abandonment permit expires and therefore are requesting a one year extension to that permit.

Please do not hesitate to contact me if you require any further information.

Sincerely,

Martin L. Jokl

Martin L. Jokl
President

MLJ/rh

cc: Manabu Tagomori

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JOHN WAIHEE
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DAN T. KOCHI

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STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

REF:WRM-LN

NOV 5 1991

Mr. Marty L. Jokl
President
Barnwell Geothermal Corporation
2828 Paa Street, Suite 2085
Honolulu, Hawaii 96819

Dear Mr. Jokl:

The Department of Land and Natural Resources acknowledges the receipt of your request for extension of Geothermal Resource Mining Leases (GRML) R-3.

Mining lease GRML R-3, Section 3(B), provides that if at the expiration of the primary term geothermal resources in commercial quantitites are not being produced from the leased lands, but the Lessee is actively engaged in drilling operations designed to drill below the depth of 1,000 feet, or, to a production zone at a lesser depth in a diligent manner, that Lease shall be continued for so long thereafter as such operations are continued with no cessation of more than 180 days, but not to exceed a period of five (5) years, and if such drilling operations are successful, as long thereafter as geothermal resources are being produced or utilized in commercial quantities except for the 65-year limit of the lease.

The Department has reviewed your earlier exploration activity conducted under mining lease R-3 and your current plans for exploration/development proposed between Barnwell and Morgan Oil Ltd. of Kentucky. We have no objections to your proposal to conduct further exploration activity within the mining lease area, or to your plans to apply for all applicable permits necessary to undertake this effort.

Accordingly, a five-year extension of lease R-3 beyond the primary 10-year term is hereby granted subject to all applicable terms and conditions of the lease. The new expiration date of mining lease GRML R-3 shall be August 10, 1996. Should you have any questions, please contact Manabu Tagomori, Deputy Director, at 548-7533.

Sincerely,

Dan T. Kochi

WILLIAM W. PATY

cc: Division of Land Management